

CLOSURE REMEDIAL INVESTIGATION

VOLUME I

**CHEMICAL CONTROL
CORPORATION SITE
ELIZABETH, NEW JERSEY**

**JUNE 1987
W.A. NO. 57-2L55.1**

NOTICE

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EXECUTIVE SUMMARY

The Chemical Control Site is a former waste processing facility which in the 1970's accepted various hazardous wastes for disposal or recovery. The operations of the facility were plagued with problems and irregularities. The site was closed in January, 1979 and a cleanup was initiated by the New Jersey Department of Environmental Protection (NJDEP). The cleanup lasted until April, 1980, when a fire of unknown origin broke out. After the fire the remaining wastes onsite were removed and disposed of, the top 3 feet of soil on site was removed and replaced with clean gravel fill, and a groundwater treatment system was operated. The site is now a fenced gravel lot with approximately 200 gas cylinders in overpacks awaiting final disposal.

This Closure Remedial Investigation was undertaken to determine the extent of residual contamination remaining in the environmental media on and near the site, and to determine the present-day risks that the site poses to the public health and the environment. The data collected were design to determine if further remedial measures were necessary.

Samples of the surface soil, subsurface soil, groundwater, and the surface water and sediments in the Elizabeth River were obtained. Additional data to characterize the site hydrogeology were also obtained, such as climatological data, streamflow data, and measurements of the tidally influenced stage fluctuations of the Elizabeth River.

The analytical results showed that residual contamination is present within all of the environmental media sampled onsite. The highest contaminant concentrations were found within the subsurface soil, in an "old" fill which underlies the new coarse gravel fill emplaced after the fire. These contaminants are apparently tightly bound to the old fill and do not readily enter the groundwater, which generally has low contaminant concentrations.

High concentrations of contaminants were found within the Elizabeth River sediments, while the river water itself had relatively low contaminant concentrations. Although groundwater discharges off of the site into the Elizabeth River, it is estimated that the site is not presently contributing to the river contamination. This is due to the generally low contaminant concentrations found in the groundwater and the river dilution potential. Other unidentified sources may be contributing to the river and sediment contamination.

The risk assessment estimated that the site poses little threat to the public health or the environment. This is due to the

suspected poor background environmental quality in the area, the limited potential for human exposure, and the fact that the majority of the onsite contaminants are bound in the soil matrix.

Additional data were obtained in May 1986 to broaden the data base of this investigation. Samples of the Elizabeth River water and sediments upstream from the site, of the Arthur Kill sediments, of the surface soil in the Russo Junkyard, of the surface soil in a "background" area, and of the storm sewer system adjacent to the site were obtained. Analytical results for these samples indicate that upstream sources have affected the Elizabeth River. Water samples were also collected from five manholes in the storm sewer system adjacent the site. Results for these samples indicate that the storm sewer system may be a contaminant migration pathway from both the Chemical Control Corporation Site and upstream sources.

1.0 INTRODUCTION

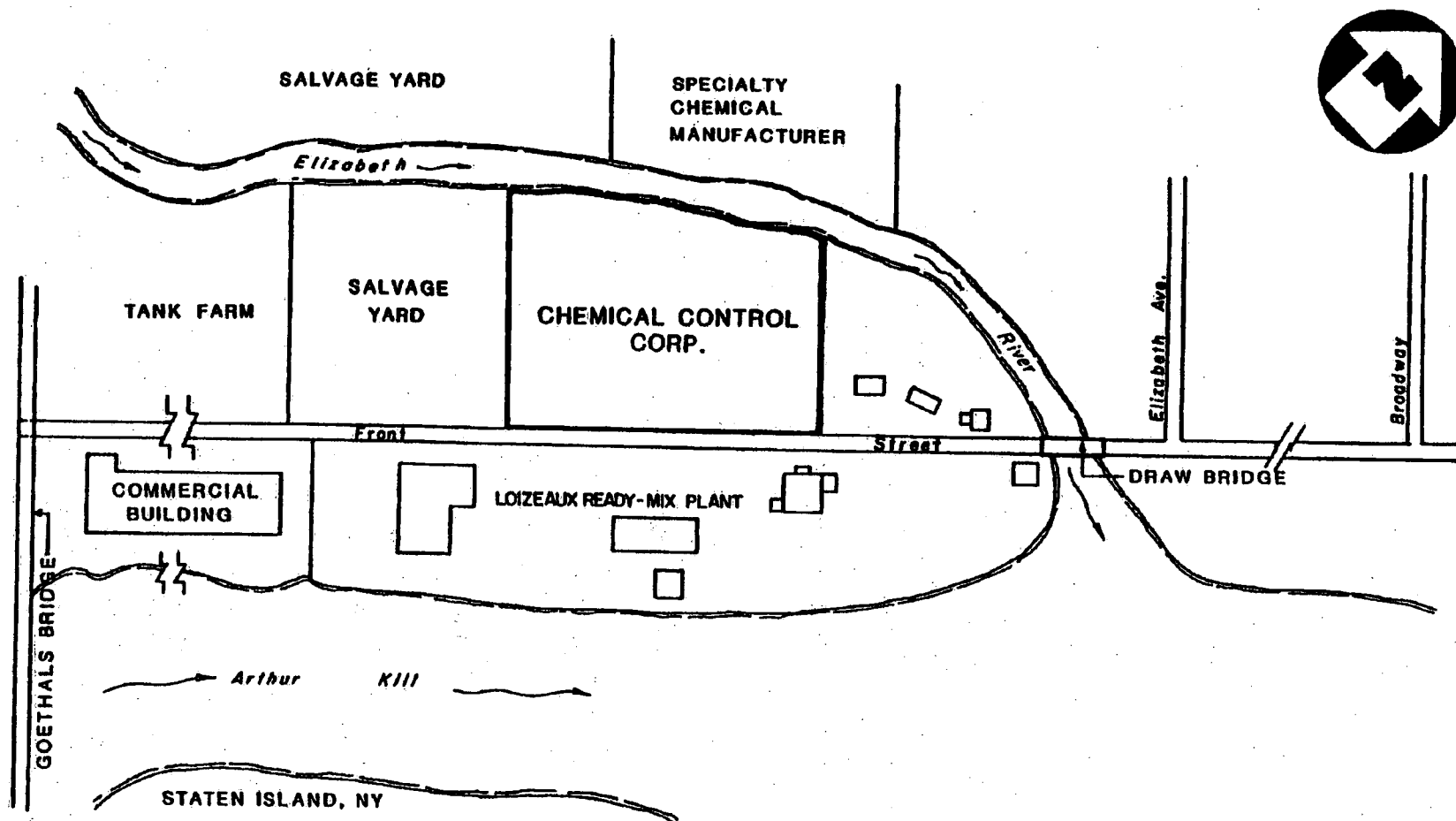
1.1 SITE HISTORY

The Chemical Control Corporation Site is a former waste processing facility which, in the 1970's, accepted various wastes for disposal or recovery by neutralization, chemical treatment, or incineration. These wastes included acids, bases, arsenic compounds, cyanide compounds, flammable solvents, compressed gases, biological agents, explosive chemicals, pyrophoric materials (spontaneously igniting), radioactive wastes, and pesticides.

The site is located in Union County at 23 South Front Street, Elizabeth, New Jersey. The property is directly adjacent to the Elizabeth River near its confluence with the Arthur Kill, as shown in Figures 1-1 and 1-2. Chemical Control Corporation was originally permitted by the State of New Jersey as a special waste facility to engage in reprocessing, reclaiming, recovering, blending, and treating hazardous wastes. The site has undergone massive cleanup efforts by NJDEP and EPA, as discussed in following sections, and is presently fenced. A limited quantity of wastes, approximately 200 gas cylinders and items recovered from the Elizabeth River, await final removal and disposal.

1.1.1 Pre-Fire Operations

In 1970, Chemical Control Corporation of Elizabeth, New Jersey, requested and received a permit to construct an incinerator/scrubber system for the purpose of incinerating various industrial wastes. The facility also had a thin film evaporation unit and an aerosol-shredder/vacuum-recovery unit. After the incinerator passed New Jersey State air quality tests in 1972, Chemical Control Corporation was issued a 5-year operating permit. Operations at the facility through the mid-1970's were frequently hampered by operating and mechanical problems, particularly those involving the incineration process. In January 1977, Elizabeth police discovered that a truck owned by Chemical Control Corporation was discharging waste solvents onto the ground adjacent to the Elizabeth River. This was the first documented illegal action by Chemical Control. Later that year, William Carracino, owner of the facility, was convicted of illegal dumping, fined \$21,000, and sent to prison. Chemical Control Corporation was also charged with operating without all necessary permits and fined \$75,000. At the time of this indictment, Carracino sold Chemical Control Corporation to Eugene Conlon and John Albert, who in turn appointed William Colleton as president.



GENERAL ARRANGEMENT
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ
 NOT TO SCALE

FIGURE 1-2



On July 31, 1977, the facility was granted a 5-year operating permit by the State of New Jersey, enabling it to discharge water into the Elizabeth River. The permit allowed the discharge of noncontact cooling water only. Late in 1977 a large stockpile of drums was first discovered at the site. Shutdowns of other major hazardous waste disposal sites in the state (Kin-Buc Landfill and Rollins Environmental Services treatment facility) increased the volume of wastes shipped to the Chemical Control Corporation facility and was a factor in the stockpiling of drums at the facility in 1977-1978. Throughout the latter stages (1977-1979) of the facility's period of operation, the NJDEP conducted frequent inspections at the facility.

On March 3, 1978, in response to the observed stockpiling of drums at the facility, the NJDEP issued an administrative order requiring the facility to dispose of 1,200 drums per month, eliminate the entire stockpile within 2 years, and clean up and fence the site. Chemical Control Corporation was also prohibited from accepting any new wastes that could not be disposed within 60 days. The facility apparently continued operations in violation of this order, as evidenced by the continued buildup of drums at the site without apparent cleanup efforts by Chemical Control Corporation.

In May of 1978, NJDEP representatives discovered solvents contaminating the storm sewer lines near the site during one of its inspections, a fact which indicated possible dumping of wastes into storm sewers. An inspection in July of 1978, by the Federal Occupational Safety and Health Administration (OSHA), revealed numerous violations of regulations and resulted in the facility's being cited by OSHA and fined. The most serious violations discovered were the lack of segregation of the various wastes and other improper storage procedures. The citation issued required that storage violations be corrected by July 1, 1979. On November 2, 1978, the EPA imposed a fine of \$10,000 on Chemical Control Corporation for violations of the oil pollution prevention regulations stated in the Clean Water Act. During an inspection in December 1978, an NJDEP representative noted drums stacked along the riverbank and the fact that discharges from some of the drums were migrating into the Elizabeth River. An estimated 35,000 to 50,000 drums were present at the facility during this time. Drums were stacked in tiers up to five levels high in some areas. Many of the drums were severely deteriorated, and some were leaking.

On January 14, 1979, three drums at the site exploded and caught fire. A local fire company responded to the fire and extinguished it. Five days after this incident a court injunction was filed against Chemical Control Corporation and its parent company, the Northern Pollution Control Company of New York, in response to a request by NJDEP to close the Elizabeth facility. The site was closed and placed in operational receivership on March 8, 1979 for violations of

environmental regulations. John Boyle was designated the court-appointed receiver for the site.

1.1.2 Pre-Fire Cleanup

In March 1979, the Office of Hazardous Substances Control (OHSC) of NJDEP developed a cleanup strategy for the estimated 50,000 drums and requested bids from cleanup contractors. While escorting contractors on a tour of the site, OHSC discovered a previously unnoticed room referred to as the "loft area" in one of the onsite buildings. This area contained more than 1,000 drums of improperly and incompatibly packed laboratory reagents, including chemical, explosive, infectious, and radioactive agents. It appeared that some segregation had been carried out by Chemical Control wherein useful and recyclable chemicals had been sorted from the useless chemicals. Some additional laboratory packs were also found outside the buildings around the site.

Cleanup began on April 28, 1979, by OHSC and its contractor, Coastal Services, Inc. (later Peabody Coastal). This program was set up in two phases, as follows:

Phase I:

- Stabilize the "loft area."
- Mitigate hazards posed by lab packs throughout the site.
- Overpack leaking drums.
- Control and contain discharges.
- Work in conjunction with the Chemical Industrial Council and EPA to develop analytical protocol for drum contents identification analysis.

Phase II:

- Sample all remaining drums.
- Segregate all containers by physical/chemical characteristics. Separate incompatible materials.
- Arrange for disposal of remaining materials.

Phase I of the cleanup plan was divided into three major tasks. Task I involved relocating a large number of drums throughout the site in order to create corridors of access. Task II involved the mitigation of hazards posed by the "loft area" as well as handling the laboratory packs found throughout the site. The third major task of Phase I cleanup was the "generator recovery program." The generator recovery program was voluntary and involved identifying containers and matching them with the generating company. A total of 21 generators were identified, including American Cyanamid, American Hoechst, Dura Bond, 3M, Merck, National Starch, Reichold, Rohm & Haas, Tenneco, and Thiokol. (Identities of generators who removed drums from the site remained confidential.)

From April 28, 1979, to April 21, 1980, the NJDEP processed and removed wastes containing nitroglycerin, picric acid, benzoyl peroxide, and 24 gallons of other liquid explosives. Radioactive materials totaling 7 pounds were removed and disposed by the NJDEP Bureau of Radiation. Other highly dangerous material that was safely removed from the site included: 10 pounds of an etioloical (infectious) agent, 83 compressed gas cylinders, 8,668 waste-filled drums, 772 drums containing processed "lab pack" materials, 55,400 pounds of bulk solids, and 1,800 gallons of bulk liquids. The removal of these wastes helped to reduce the severity of the April 21, 1980 fire and kept a possible catastrophic explosion from occurring. The only task of Phase I to be completed prior to the fire was the stabilization of the "loft area." The remaining tasks were in various stages of completion. Phase II cleanup never started because of the fire.

On or about May 1, 1979, EPA performed a site inspection to evaluate the site for possible remedial action under existing funding programs. This inspection and following report recommended that the Chemical Control Site be classified as high priority owing to several factors including fire and explosion potential, large population exposure, large volume of waste, and extensive press coverage. On May 30 of the same year, the Mayor of Elizabeth, Thomas G. Dunn, issued an executive order declaring a state of emergency at the site.

1.1.3 The Fire

On April 21, 1980, a fire of unknown origin broke out at the site. At 10:45 p.m., the security guard on the site placed the first alarm to the Elizabeth Fire Department. A cloud of toxic gases soon developed and threatened the nearby heavily populated areas of Greater New York City.

To this date, the cause of the fire is not known. Numerous investigations by local, state, and federal agencies were conducted during and after the fire in attempts to discover whether or not the fire was the result of arson. Spontaneous ignition was considered a cause since potential sources of spontaneous ignition were known to be present on site at the time of the fire. During NJDEP's Phase I actions, alkali metals such as sodium and substances having pyrophoric (spontaneous combustion) properties were discovered on site. While the pre-fire cleanup eliminated many of the known sources before the fire, it is generally believed that quantities of these types of materials were present in the drum piles.

By 11:22 p.m., the fire had gone to four alarms. A contingency plan previously developed by the City of Elizabeth, in cooperation with State and Federal agencies, was activated, and personnel from the NJDEP and the New Jersey State Police (NJSP) were on the scene by midnight. Many small explosions and several large explosions were observed. Some explosions sent

fireballs hundreds of feet into the air. More than 20 fire-fighting units as well as two fireboats from New York City and one fireboat from the United States Coast Guard were involved. Institutional response to the blaze included NJDEP, New Jersey Department of Health (NJDOH), New Jersey State Police, United States Coast Guard, EPA, New York Fire Department, Elizabeth Fire Department, Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), and local agencies. As a precautionary measure, public schools in Elizabeth and Staten Island were closed; Turnpike Exits 13 and 14 and the Goethals Bridge, which is adjacent to the site, were closed; and residents in the City of Elizabeth and areas downwind were requested to stay indoors, with doors and windows closed. Fire fighting was mainly directed at stopping the spread of the fire, rather than trying to extinguish the blaze. The materials involved were too flammable and the fire itself too hot to fight directly. Emergency response during the fire was rapid enough to attempt to evaluate the level of hazard associated with the fire. Air monitoring began almost immediately and continued throughout the course of the fire. The results of the air testing showed negative results for hydrogen cyanide, phosgene, and hydrogen chloride. Organic analysis indicated low concentrations of simple aromatic hydrocarbons (benzene, toluene, xylenes) below 100 parts per billion. Acid fumes and mist were present, as evidenced by highly corrosive effects on structures in the area.

During the fire, it is estimated that temperatures at the fire's center reached 2,000°F, allowing efficient thermal degradation of most materials burned. As the fire was brought under control, incompletely combusted organic chemicals were released into the atmosphere. By 9:19 a.m. on April 22, the fire was declared under control. Throughout the day, constant streams of water were pumped on the hot debris. The waste materials in the area remained very hot. When an interruption of the water stream occurred, small flare-ups of the waste were observed.

The potential severity of the impact of the blaze with regard to public health and safety was mitigated by several fortunate circumstances. First, the fire started at night when industrial activity around the site was at a minimum, and thereby reduced possible exposure to workers in the vicinity. Second, the wind direction was from the west and moderately strong throughout the fire; therefore, the bulk of the smoke plume was directed out over the Atlantic Ocean and away from the large population centers. Additionally, the strong winds helped disperse the materials in the plume. Firefighters and others near the fire reported suffering ill effects. Common symptoms reported included irritated throats, eyes, lips, and skin; temporary loss of appetite; vomiting; diarrhea; and eye strain. In some cases symptoms lasted up to six months.

1.1.4 Post-Fire Cleanup

During the course of the fire, several million gallons of water were poured onto the Chemical Control property. On the morning of April 22, the Elizabeth River was red from the contaminated runoff that had originated at Chemical Control. NJDEP chemical analysis of the runoff indicated levels of organics in excess of water quality standards. In response to the contamination of the Elizabeth River and the Arthur Kill, commercial fishing, recreational fishing, crabbing, and shell fishing were banned in neighboring waters. Cleanup work at the site was resumed after the fire by NJDEP, using O.H. Materials, Inc., as the prime contractor. O.H. Materials, Inc., was selected as the prime contractor for the post-fire phase of the cleanup, based on their technical proposal and their demonstrated ability to perform the work efficiently. Post-fire cleanup operations were divided into three phases. The first phase consisted of immediate remediation of fire-related problems. The second phase included sampling, analysis, characterization, segregation, removal, and disposal of all the remaining contaminated material. The third phase was provisional closure of the site.

To prevent runoff from entering the Elizabeth River, a dike was constructed along the bank of the river. The dike was completed after two access roads were constructed from Front Street to the river. This construction required removal of barrels from the planned access road locations and from the river bank. After completion of the dike, contaminated surface water was treated by an activated carbon treatment system and was discharged to the Arthur Kill. This system was installed and maintained by the EPA. Catch basins in the vicinity of Chemical Control were blocked to prevent contaminated materials from entering the nearby waterways.

Drummed materials were segregated according to physical characteristics: empty, solid, or liquid. Empty drums were crushed and disposed of at a secure landfill. Liquids and solids were sampled and stored until their analyses were received. Because of limited space on the site, segregation of contaminated materials was difficult. The NJDEP received permission through the governor's office to use the Loizeaux Concrete Company, across the street from the Chemical Control property, as a staging area. Once liquids were sampled, identified, and repacked, they were shipped to Rollins Environmental Services, Bridgeport, New Jersey, for incineration. In all, 250,000 gallons of bulk liquids were sampled, identified, and disposed of during post-fire cleanup. Solids were deposited into compatible sludge piles, neutralized, and then shipped to the CECOS International Landfill at Niagara Falls, New York.

Buildings left standing after the fire were subsequently demolished. The rubble was treated as contaminated material and

shipped to a licensed facility. Additional buried drums, gas cylinders, and other containers were unearthed during the excavation of contaminated soils. During this operation, a previously undetected discharge pipe was found emptying into the Elizabeth River.

In September 1980, two tasks remained: (1) 2,000 to 3,000 drums of laboratory-packed chemicals still remained to be processed and (2) O.H. Materials, Inc., was to perform a hydrogeological survey on the site to determine the extent of groundwater contamination and to evaluate the effects of contamination on surface-water quality in the area. Once this stage was completed, the Loizeaux Company property was no longer needed. The property was decontaminated and returned to its owners.

The NJDEP and Office of Hazardous Substances Control determined that the projected discharge of contaminants to the groundwater warranted the construction of a small-scale water recovery system. The initial groundwater recovery system consisted of one line of well points to provide data on groundwater pumpage and to produce representative samples of contaminated groundwater for treatability tests and groundwater profiles. A pilot-scale treatment system was installed in November 1980 and was found to be effective in removing contamination from the groundwater at the Chemical Control Site. A full-scale treatment system was then designed. The system included the following components: (1) chemical precipitation and clarification for removal of heavy metals, (2) steam stripper for removal of volatile and semi-volatile organics, (3) sparging systems, (4) carbon filters for the removal of nonvolatile organics, and (5) fume scrubbers.

The treatment system included vacuum receivers that collected the influent groundwater and pumped it to the clarifier. Caustic soda and flocculant were added in the clarifier to facilitate metals removal. Sludge from the clarifier system was sent to the sludge drying bed. Sludge generated in this fashion was disposed of in the general bulk solids pile that was operated on the site. After being clarified, the semitreated groundwater was routed to the aeration stripping chamber for removal of volatile organics. Four pools were used as temporary storage areas for the groundwater, as needed, to balance the various system treatment rates, and for sampling to analytically check the progress of the treatment. Gases generated by the aeration stripping chamber were directed through two vapor phase scrubbers. After stripping, the groundwater was sent to the carbon filter system for final polishing. The treated water was then recycled back through the system or discharged to the Elizabeth River. The effluent discharged to the river had to meet discharge criteria of 100 parts per million (ppm) total organic carbon (TOC). O.H. Materials, Inc., had a mobile laboratory on the site and performed these TOC analyses as required.

The groundwater treatment system operated around-the-clock, treating approximately 45,000 gallons of water every 24 hours. The onsite lab analyzed between 30 and 100 effluent samples per day. The system was dismantled in May of 1981 owing to lack of State and Federal funds. The possibility of additional cleanup of groundwater using biological treatment was discussed by concerned agencies but eventually rejected as not being cost-effective or necessary.

A ground-penetrating radar survey was conducted from October 20 to 24, 1980, in hopes of resolving the question of whether barrels were located on the bottom of the Elizabeth River. The survey was inconclusive, but several targets were identified that may have been indicative of submerged barrels or other metal objects.

Post-fire cleanup operations involved removal of the following quantities of wastes:

- Removal and disposal of approximately 36,450 crushed drums.
- Removal and disposal of 3,703 whole drums.
- Sampling, removal, and/or treatment of 4,500 drums of highly toxic liquid hazardous waste.
- Reclamation of 525,000 pounds of structural steel.
- Removal and disposal of 3,000 truckloads of rubble.
- Removal and disposal of 105 million pounds of solid hazardous wastes.
- Removal of the top 3 feet of soil from the site, replacing it with clean, crushed rock.
- Sampling, segregation, and disposal of more than 1000 laboratory packs.

Catch basins and sewer lines were damaged during the response to the fire. These areas were rehabilitated as a first phase remedial action funded by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This rehabilitation was completed in October of 1985.

1.2 NATURE AND EXTENT OF THE PROBLEM

Although the major sources of contamination had been removed, the amount of residual contamination that remained in the surface soil, subsurface soil, groundwater, and in the Elizabeth River sediments was not known. This information, had to be

known to determine if the site continued to pose a threat to the public health and the environment.

1.3 REMEDIAL INVESTIGATION SUMMARY

This investigation attempted to determine the existence of contamination, the plausible migration and release pathways, and the effects of present-day contaminant release on the public health and the environment. The investigation was designed to characterize the site under present day conditions. The knowledge gained from the investigation was designed to evaluate the need for any additional remedial measures.

The investigation activities included installing monitoring wells and sampling the surface soils, subsurface soils, groundwater, sediments in the Elizabeth River, and the river water itself. Additional data to characterize the site hydrogeology, such as tidally influenced stage fluctuations in the Elizabeth River, river flow records during the period of study, and climatological records were also obtained.

A magnetometer survey was originally planned to determine the existence of buried drums or gas cylinders on the site. However, it was determined jointly by USEPA and NUS personnel that this survey would prove ineffective. The industrial activity in the area would cause unacceptably high background readings. Individual drums or cylinders would not be reliably detected. Therefore the magnetometer survey was not conducted.

1.4 OVERVIEW OF CLOSURE REMEDIAL INVESTIGATION REPORT

Section 2.0 of the report presents the site features investigation. Section 3.0 presents an overview of the contaminants found and basic information on their physical and chemical characteristics relative to their environmental transport. Section 4.0 discusses the hydrogeologic investigation, including site specific soil, geological, and groundwater information. Section 5.0 addresses the surface water regime, including the Elizabeth River water quality and sediment contamination. Section 6.0 presents the risk assessment of the potential site effects on the public health and the environment.

2.0 SITE FEATURES INVESTIGATION

2.1 DEMOGRAPHY

The site is located in a highly industrialized area of Elizabeth, New Jersey. One residential home and a commercial boating establishment are located on South Front Street, east of the site between the site boundary and the Elizabeth River. The remainder of South Front Street is occupied by industrial establishments. The more densely populated section of Elizabeth is located within one half-mile of the site, across the Elizabeth River.

2.2 LAND USE

Land usage in the immediate site vicinity is industrial, with the exception of the one residence. The site is bordered on the east by the abandoned Loizeaux Ready-Mix office building, on the west by the Russo junk yard, on the north by the Elizabeth River, and on the south, across South Front Street, by the Loizeaux Ready-Mix plant. The Chemical Control property itself comprises approximately 1.9 acres. The site is completely fenced with locked gates to prevent access. The site appears to be an empty gravel lot, with the exception of the overpacked gas cylinders still remaining from the post-fire cleanup.

2.3 NATURAL RESOURCES

Natural resource development is minimal because of the highly industrial nature of the area. Several million gallons of contaminated runoff entered the Elizabeth River when the fire was being fought. As a result, commercial fishing, recreational fishing, crabbing, and shell fishing were prohibited by the NJDEP in neighboring waters.

2.4 CLIMATOLOGY

Table 2-1 presents average annual precipitation and temperature data recorded at the Newark Airport. Table 2-2 presents rainfall data recorded at the Newark Airport during the period of this Remedial Investigation.

TABLE 2-1
CLIMATOLOGICAL DATA
CHEMICAL CONTROL CORPORATION

<u>Month</u>	<u>Average Precipitation (Inches)</u>	<u>Average Temperature (°F)</u>
January	3.13	31.3
February	3.05	32.8
March	4.15	41.2
April	3.57	52.1
May	3.59	62.3
June	2.94	71.5
July	3.85	76.8
August	4.30	75.5
September	3.66	68.2
October	3.09	57.2
November	3.59	46.5
December	<u>3.42</u>	35.5
Total	42.34	

Source - NOAA records at Newark Airport

TABLE 2-2
PRECIPITATION DATA
CHEMICAL CONTROL CORPORATION

<u>Date</u>	<u>Precipitation (inches)</u>	<u>Date</u>	<u>Precipitation (inches)</u>
December 1985		January 1986	
1	0.39/0	1	T/0
2	0.11/T	3	0.35/0
3	T/T	5	0.40/T
5	0.06/0.60	6	T/T
6	0.35/3.10	13	T/T
11	0.17/0		
12	0.20/0		
13	0.12/T		
14	T/T		
17	T/T		
20	0.06/0.5		
21	T/T		
22	T/T		
23	0.02/0.20		
24	T/0		
25	T/T		
26	T/T		
28	0.10/0.20		
31	T/0		

Note - Rainfall/Snow

- T = Trace

Source - National Weather Service at Newark Airport

3.0 HAZARDOUS SUBSTANCES INVESTIGATION

3.1 WASTE TYPES

Table 3-1 presents a list of the HSL organic and inorganic chemicals detected in the samples collected during the NUS RI.

Volatile, acid and base/neutral extractable organic chemicals, pesticides, and polychlorinated biphenyls were identified. A number of inorganic species were also detected. The inorganic chemicals may be present as a result of past contaminant release or may be naturally occurring environmental trace chemicals.

The extent of residual contamination present at the site cannot be delineated based on available data. An exhaustive environmental sampling program would be required to adequately characterize this aspect of site contamination. However, the available data are considered sufficient to infer contaminant release and potential health and environmental impacts. Additional sampling and analysis will be performed to augment remedial design considerations and to evaluate the offsite environmental quality.

3.2 WASTE COMPONENT CHARACTERISTICS AND BEHAVIOR

Table 3-2 presents a tabulation of chemical-physical parameters for the organic HSL chemicals detected at the site. Parameters indicative of the environmental transport and fate of the HSL organic substances are presented, including vapor pressures, water solubilities, octanol/water and soil/sediment adsorption coefficients, and specific gravities. The parameters provided in this table will be referenced as contaminant release and transport are discussed in the remainder of the document. Inorganic chemical transport and fate will be discussed as necessary upon comparison with background levels in Section 5.0. A brief summary of the relevance of the organic chemical mobility parameters is provided below.

- Water solubility provides an indication of the relative water contamination potential of various chemicals. The rate at which a chemical is leached from a waste deposit by infiltrating precipitation is proportional to its water solubility. More soluble chemicals are expected to enter the water table much more readily than less soluble chemicals. The water solubilities presented in Table 3-2 indicate that the volatile organic compounds are generally several orders of magnitude more water-soluble than the base/neutral extractable compounds and substantially more water soluble than the polychlorinated biphenyls and pesticides.

TABLE 3-1

**HSL ORGANIC AND INORGANIC CHEMICALS DETECTED
AT THE CHEMICAL CONTROL SITE
UNION COUNTY, NEW JERSEY
(Based on samples collected by NUS Corporation; 1985-1986)**

<u>Organic Chemicals</u>	<u>Inorganic Chemicals</u>
<u>Volatile</u>	aluminum
acetone	antimony
2-butanone	arsenic
4-methyl-2-pentanone	barium
	beryllium
	cadmium
benzene	calcium
toluene	chromium
ethylbenzene	cobalt
total xylenes	copper
styrene	iron
chlorobenzene	lead
	magnesium
1,1,2,2-tetrachloroethane	manganese
1,1,1-trichloroethane	mercury
1,1-dichloroethane	nickel
1,2-dichloroethane	potassium
chloroethane	selenium
	silver
tetrachloroethene	sodium
trichloroethene	thallium
1,2-dichloroethene	tin
vinyl chloride	vanadium
	zinc
carbon tetrachloride	
chloroform	
methylene chloride	
chloromethane	
bromomethane	
carbon disulfide	
<u>Pesticides/PCBs</u>	
alpha-BHC	
4,4'-DDT	
4,4'-DDD	
4,4'-DDE	

TABLE 3-1
HSL ORGANIC AND INORGANIC CHEMICALS DETECTED
AT THE CHEMICAL CONTROL SITE
UNION COUNTY, NEW JERSEY
(Based on samples collected by NUS Corporation; 1985-1986)
PAGE TWO

Organic Chemicals

Pesticides/PCBs

endosulfan sulfate

dieldrin

Arochlor 1242

Arochlor 1254

Arochlor 1260

Acid Extractables

phenol

2-methylphenol

4-methylphenol

2,4-dimethylphenol

Base/Neutral Extractables

bis(2-ethylhexyl)phthalate

di-n-octyl phthalate

di-n-butyl phthalate

diethyl phthalate

butylbenzyl phthalate

dimethyl phthalate

acenaphthene

acenaphthylene

anthracene

benzo(a)anthracene

benzo(b)fluoranthene

benzo(k)fluoranthene

benzo(g,h,i)perylene

benzo(a)pyrene

chrysene

dibenz(a,h)anthracene

fluoranthene

fluorene

indeno(1,2,3-cd)pyrene

naphthalene

2-methylnaphthalene

TABLE 3-1
HSL ORGANIC AND INORGANIC CHEMICALS DETECTED
AT THE CHEMICAL CONTROL SITE
UNION COUNTY, NEW JERSEY
(Based on samples collected by NUS Corporation; 1985-1986)
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Organic Chemicals

Base/Neutral Extractables

phenanthrene
pyrene
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
1,2,4-trichlorobenzene

n-nitrosodiphenylamine
4-chloroaniline

benzoic acid
benzyl alcohol
bis(2-chloroethoxy)methane
dibenzofuran
isophorone

TABLE 3-2

MOBILITY PARAMETERS FOR ORGANIC CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE

PP #	CAS #	Chemical	Vapor Pressure mm Hg (@ 20°C)	Water Solubility mg/l (@ 20°C)	Octanol/Water Partition Coefficient(log ₁₀)	Soil/Sediment Adsorption Coefficient(log ₁₀)	Specific Gravity (20°C/4°C)	Mobility Index (7)
Ketones								
	67-64-1	acetone	270 (@ 30°C) (1)	6×10^5 (27)	-0.24 (1)	-0.45/1.25 (2)	0.791 (1)	6.9/8.7
	78-93-3	2-butanone	78 (1)	3.6×10^5 (1)	0.28 (1)	0.05/1.52 (2)	0.805 (1)	5.9/7.4
	108-10-1	4-methyl-2-pentanone	6 (1)	1.9×10^4 (1)	1.68 (6)	1.47/2.29 (2)	0.8017 (1)	2.8/3.5
Monocyclic Aromatics								
(4V)	71-43-2	benzene	76 (1)	1,780 (1)	2.13 (1)	1.92 (3)	0.879 (1)	3.2
(38V)	100-41-4	ethylbenzene	7 (1)	152 (1)	3.15 (1)	2.93 (4)	0.867 (1)	0.10
		total xylenes (9)	6 (1)	180 (1)	3.02 (1)	2.84 (4)	0.870 (1)	0.19
(86V)	108-88-3	toluene	22 (1)	515 (1)	2.69 (1)	2.54 (4)	0.867 (1)	1.5
(7V)	108-90-7	chlorobenzene	8.8 (1)	500 (1)	2.84 (1)	2.64 (4)	1.1066 (1)	1.0
	100-42-5	styrene	5 (1)	300 (1)	2.69 (28)	2.62 (4)	0.9045 (@ 75°C/4°C)(1)	0.56
(25D)	95-50-1	1,2-dichlorobenzene	(1) (1)	100 (1)	3.38 (1)	3.13 (4)	1.305 (1)	-1.1
(26B)	541-73-1	1,3-dichlorobenzene	2.3 (6)	69 (@ 22°C) (1)	3.38 (1)	3.17 (4)	1.288 (1)	-0.97
(27B)	106-48-7	1,4-dichlorobenzene	0.6 (1)	49 (@ 22°C) (1)	3.39 (1)	3.22 (4)	1.458 (1)	-1.8
	120-82-1	1,2,4-trichlorobenzene	0.42 (6)	19 (@ 22°C) (1)	4.26 (6)	3.86 (4)	1.574 (@ 10°C/4°C)(1)	-2.9
(65A)	108-95-2	phenol	0.2 (1)	82,000 (@ 15°C) (1)	1.46 (1)	1.9 (10)	1.070 (1)	2.3
	95-48-7	2-methylphenol	0.24 (@ 25°C) (1)	31,000 (@ 40°C) (1)	1.93 (1)	1.39 (10)	1.041 (1)	2.5
	108-39-4	4-methylphenol	0.04 (1)	24,000 (@ 40°C) (1)	1.93 (1)	1.52 (10)	1.035 (1)	1.7
	105-67-9	2,4-dimethylphenol	0.06 (6)	17,000 (6)	2.50 (1)	2.45 (10)	1.038 (1)	0.56
Halogenated Aliphatics								
	79-34-5	1,1,2,2-tetrachloroethane	5 (1)	2,900 (1)	2.58 (6)	1.92 (8)	1.60 (1)	2.2
(11V)	71-55-6	1,1,1-trichloroethane	100 (1)	4,400 (1)	2.17 (6)	1.78 (8)	1.350 (1)	4.0
(10V)	107-06-2	1,2-dichloroethane	61 (1)	8,700 (1)	1.48 (6)	1.52 (8)	1.250 (1)	4.2
(13V)	75-34-3	1,1-dichloroethane	180 (1)	5,500 (1)	1.79 (6)	1.83 (8)	1.174 (1)	4.4
(16V)	75-00-3	chloroethane	1,000 (1)	5,740 (1)	1.54 (1)	1.52 (8)	0.92 (0°C/4°C) (1)	5.2
(85V)	127-18-4	tetrachloroethene	14 (1)	150 (@ 25°C) (1)	2.60 (1)	2.6 (8)	1.626 (1)	0.76
(87V)	79-01-6	trichloroethene	80 (1)	1,100 (@ 25°C) (1)	2.28 (6)	2.09 (8)	1.46 (1)	2.7
(30V)	156-60-5	1,2-dichloroethene (26)	200 (@ 14°C) (1)	600 (1)	1.48 (6)	2.17 (8)	1.260 (1)	2.9

TABLE 3-2
MOBILITY PARAMETERS FOR ORGANIC CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
PAGE TWO

PP #	CAS #	Chemical	Vapor Pressure mm Hg (@ 20°C)	Water Solubility mg/l (@ 20°C)	Octanol/Water Partition Coefficient(log ₁₀)	Soil/Sediment Adsorption Coefficient(log ₁₀)	Specific Gravity (20°C/4°C)		Mobility Index (7)
Halogenated Aliphatics (cont.)									
(29V)	75-35-4	1,1-dichloroethene	500 (1)	400 (1)	1.48 (6)	2.26 (8)	1.218 (1)	3.0	Very mobile
(88V)	75-01-4	vinyl chloride	2,660 (@ 25°C) (1)	1,100 (@ 25°C) (1)	0.60 (6)	1.91 (8)	0.9121 (1)	4.6	Very mobile
(6V)	56-23-5	carbon tetrachloride	90 (1)	800 (1)	2.64 (1)	2.2 (8)	1.59 (1)	2.7	Very mobile
(23V)	67-66-3	chloroform	160 (1)	8,000 (1)	1.97 (1)	1.59 (8)	1.489 (1)	4.5	Very mobile
(44V)	75-09-2	methylene chloride	350 (1)	20,000 (1)	1.25 (6)	1.28 (8)	1.327 (1)	5.6	Extremely mobile
	74-87-3	chloromethane	3,800 (1)	4,000 cm ³ /L (gas) (1)	NA	NA	0.991 (1)	NC	
	74-83-9	bromomethane	1,420 (6)	900 (1)	1.1 (6)	2.06 (10)	1.73 (@ 0°C/0°C)(1)	4.0	Very mobile
Phthalate Esters									
(66B)	117-81-7	bis(2-ethylhexyl) phthalate	2.7 x 10 ⁻⁷ (6)	1.3 (6)	8.73 (6)	5.8 (10)	0.99 (20°C/20°C) (1)	-12	Immobile
(66B)	84-74-2	di-n-butyl phthalate	0.1 (6)	13 (@ 25°C) (6)	5.2 (6)	3.9 (10)	1.0465 (1)	-3.8	Slightly mobile
(70B)	84-66-2	diethyl phthalate	0.05 (@ 70°C) (6)	210 (1)	3.22 (6)	2.9 (10)	1.12 (25°C/25°C) (1)	-1.9	Slightly mobile
(67B)	85-68-7	butyl benzyl phthalate	8.6 x 10 ⁻⁶ (1)	2.9 (1)	4.78 (1)	3.8 (10)	1.1 (25°C/25°C) (1)	-8.4	Immobile
(69B)	117-84-0	di-n-octyl phthalate	1.2 (@ 200°C) (1)	0.285 (1) (24°C)	9.2 (6)	6.1 (10)	0.99 (20°C/20°C) (1)	-6.6	Slightly mobile
(71B)	131-11-3	dimethylphthalate	0.01 (1)	5000 (1)	2.12 (6)	2.3 (10)	1.19 (25°C/25°C) (1)	-0.60	Slightly mobile
Polynuclear Aromatics									
(55B)	91-20-3	naphthalene	1 (@ 53°C) (1)	30 (1)	3.37 (1)	1.72/3.16 (4)	1.15 (1)	-1.7/-0.24	Slightly mobile
	91-57-3	2-methylnaphthalene	1 (@ 53°C) (11)	28-28 (@ 25°C) (12)	4.26 (14)	2.2/3.82 (4)	0.994 (1)	-2.4/-0.77	Slightly mobile
(39B)	208-44-0	fluoranthene	10 ⁻⁸ -10 ⁻⁴ (6)	0.285 (@ 25°C) (1)	5.33 (6)	4.84 (4)	NA	-8.4	Immobile
(84B)	129-00-0	pyrene	6.85 x 10 ⁻⁷ (6)	0.14 (@ 25°C) (6)	5.32 (6)	4.91 (4)	NA	-11.9	Immobile
(72B)	56-55-3	benzo(a)anthracene	5 x 10 ⁻⁹ (6)	0.014 (@ 25°C) (6)	5.61 (6)	5.34 (4)	NA	-15.5	Immobile
(73B)	50-32-8	benzo(a)pyrene	5 x 10 ⁻⁹ (6)	0.0038 (@ 25°C) (6)	6.04 (6)	5.72 (4)	NA	-16.4	Immobile
(75B)	207-08-9	benzo(k)fluoranthene	9.59 x 10 ⁻¹¹ (6)	0.0016 (@ 25°C) (15)	6.84 (6)	6.22 (4)	NA	-19	Immobile
(76B)	218-01-9	chrysene	10 ⁻¹¹ -10 ⁻⁶ (6)	0.006 (@ 25°C) (1)	5.61 (6)	5.44 (4)	1.274 (1)	-13.7	Immobile
(78B)	120-12-7	anthracene	1.95 x 10 ⁻⁴ (6)	1.29 (@ 25°C) (1)	4.45 (1)	4.2 (4)	1.25 (1)	-7.8	Immobile
(79B)	191-24-2	benzo(g,h,i)perylene	10 ⁻¹⁰ (6)	0.00028 (@ 25°C) (1)	7.23 (6)	6.64 (4)	NA	-20	Immobile
(80B)	86-73-7	fluorene	10 ⁻³ -10 ⁻² (6)	1.9 (@ 25°C) (1)	4.18 (6)	3.97 (4)	NA	-6.7	Immobile
(81B)	85-01-8	phenanthrene	6.8 x 10 ⁻⁴ (6)	0.816 (@ 21°C) (6)	4.46 (1)	4.28 (4)	1.025 (1)	-7.5	Immobile
(83B)	193-39-8	indeno(1,2,3-cd) pyrene	10 ⁻¹⁰ (6)	0.0034 (@ 25°C) (6)	8.3 (16)	5.87 (4)	NA	-18	Immobile
(77B)	208-86-8	acenaphthylene	10 ⁻³ -10 ⁻² (6)	3.42 (6)	4.33 (6)	4.01 (4)	NA	-5.5	Immobile
(74B)	205-99-2	benzo(b)fluoranthene	10 ⁻¹¹ -10 ⁻⁶ (6)	0.009 (15)	6.57 (6)	6.26 (4)	NA	-14	Immobile
(82B)	53-70-3	dibenz(a,h)anthracene	10 ⁻¹⁰ (6)	0.0005 (@ 25°C) (6)	6.86 (23)	6.38 (4)	NA	-20	Immobile
(1B)	83-32-9	acenaphthene	10 ⁻³ -10 ⁻² (6)	3.42 (@ 25°C) (6)	4.33 (6)	4.22 (4)	0.899 (1)	-6.7	Immobile

TABLE 3-2
MOBILITY PARAMETERS FOR ORGANIC CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
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PP #	CAS #	Chemical	Vapor Pressure mm Hg (@ 20°C)	Water Solubility mg/l (@ 20°C)	Octanol/Water Partition Coefficient(log ₁₀)	Soil/Sediment Adsorption Coefficient(log ₁₀)	Specific Gravity (20°C/4°C)	Mobility Index (7)	
Pesticides/PCBs and Related Compounds									
(54B)	78-59-1	Isophorone	0.38 (1)	12,000 (1)	1.7 (6)	1.85 (10)	0.92 (1)	1.8	Very mobile
(102B)	318-84-6	BHC(alpha)	2.5 x 10 ⁻⁵ (6)	2.0 (@ 25°C) (6)	3.81 (6)	3.46 (10)	NA	-7.8	Immobile
(92P)	50-29-3	4,4'-DDT	1.9 x 10 ⁻⁷ (1)	0.0034 (@ 25°C) (1)	6.19 (1)	4.89 (10)	NA	-14	Immobile
(94P)	74-54-8	4,4'-DDD	10.2 x 10 ⁻⁷ (@ 30°C) (6)	0.09 (@ 25°C) (6)	5.99 (6)	4.47 (10)	NA	-12	Immobile
(93P)	72-55-9	4,4'-DDE	6.5 x 10 ⁻⁶ (6)	0.040 (1)	4.28 (1)	3.66 (10)	NA	-10	Immobile
(90P)	60-57-1	dieldrin	1.8 x 10 ⁻⁷ (@ 25°C) (1)	0.1 (1)	5.6 (25)	4.31 (10)	1.76 (1)	-12	Immobile
(97P)	1031-07-08	endosulfan sulfate	9 x 10 ⁻³ (20)	0.117 (6)	3.66 (6)	3.76 (10)	NA	-6.7	Immobile
(106P)	53489-21-9	PCB-1242	4.06 x 10 ⁻⁴ (6)	0.10 (@ 24°C) (1)	5.58 (6)	3.99 (10)	1.35 (6)	-8.4	Immobile
(107P)	11097-89-1	PCB-1254	7.7 x 10 ⁻⁵ (6)	0.024 (6)	6.03 (6)	4.59 (10)	1.50 (6)	-10	Immobile
(111P)	11096-82-5	PCB-1260	4.1 x 10 ⁻⁵ (6)	0.003 (6)	6.11 (6)	4.87 (10)	1.58 (6)	-12	Immobile
Miscellaneous Compounds									
(61B)	65-85-0	benzoic acid	0.13 (26)	2,900 (1)	1.87 (1)	2.17 (10)	1.270 (1)	0.40	Very mobile
	86-30-6	n-nitrosodiphenylamine	0.007 (26)	1,100 (21)	2.57 (6)	2.78 (10)	NA	-1.9	Slightly mobile
	100-51-6	benzyl alcohol	1 (@ 58°C) (1)	35,000 (1)	1.10 (1)	1.73 (10)	1.05 (@ 15°C/15°C)(1)	2.8	Very mobile
	75-15-0	carbon disulfide	260 (1)	2,300 (@ 22°C) (1)	1.84 (1)	2.08 (10)	1.263 (1)	3.7	Very mobile
	108-47-8	4-chloroaniline	0.015 (1)	61 (21)	1.83 (1)	2.54 (10)	1.427 (@ 19°C/4°C)(1)	-2.6	Slightly mobile
	111-91-1	bis(2-chloroethoxy) methane	F1 (6)	81,000 (6)	1.26 (6)	1.79 (10)	NA	3.1	Very mobile

TABLE 3-2

**MOBILITY PARAMETERS FOR ORGANIC CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
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Notes:

1. Verschueren
2. Lyman; Eq 4-10 and 4-8 respectively
3. Lyman; Eq 4-10
4. Lyman; Average value Eq 4-6 and 4-10
5. Lyman; fragment analysis Chapter 1. $\log Kow_{MIBK} = \log Kow_{MEK} - f_H + 2f_{CH_3} + f_{CB}$
6. Versar
7. Ford
8. Lyman; Eq 4-7
9. Average values for ortho, meta, and para xylene
10. Lyman; Eq 4-5 and 4-8, average value
11. No data available, assumed similar vapor pressure as naphthalene
12. Value provided for similar compound 1-methylnaphthalene
13. No data available, assumed similar to aldrin
14. Lyman; fragment analysis Chapter 1. $\log Kow_{2\text{-methylnaphthalene}} = \log Kow_{\text{(naphthalene)}} + f_{DCH_3}$
15. Lyman; Eq 2-20
16. Lyman; Eq 2-18
17. Lyman; Eq 4-8
18. Weast
19. Parameters presented for more toxic trans isomer.
20. Assumed similar to endosulfan
21. Lyman; Eq. 2-2
22. No information found; reported value is for similar compound diphenylamine
23. Lyman; Eq. 2-18
24. Lyman; fragment analysis Chapter 1. $\log Kow_{\text{styrene}} = \log Kow_{(C_8H_{10})} - f_{CH_3} + f_H$ (p 1-34)
25. Lyman; Eq. 2-3
26. Lyman; Eq. 14-20
27. Lyman; Eq. 2-6
28. Lyman; fragment analysis Chapter 1. $\log Kow_{\text{styrene}} = \log Kow_{(C_9H_{10})} - f_{CH_3} + f_H$ (p 1-34)
- NA Not available/applicable
- NC Not calculated

- Vapor pressure provides an indication of the rate at which a chemical volatilizes from both the soil and water matrices. It is of primary significance at environmental interfaces such as soil/air and surface water/air. Chemicals with relatively high vapor pressures (i.e., the volatile organics) may be subject to release to the ambient air via volatilization.
- The octanol/water partition coefficient is used to estimate bioconcentration factors in aquatic organisms. A linear relationship between the octanol/water partition coefficient and the uptake of chemicals by the lipid tissue of animal and human receptors (the bioconcentration factor) has been determined.
- The soils/sediment adsorption coefficient is related to the water solubility and the octanol/water partition coefficient. This parameter indicates the tendency of a chemical to bind to soil particles containing organic carbon. Chemicals with high soil/sediment adsorption coefficients generally have low water solubilities. These chemicals (such as base/neutral extractables, pesticides, and PCBs) are relatively immobile in the subsurface environment. They are preferentially bound to the soil matrix and are not subject to groundwater advection. However, these chemicals are subject to transport via erosional processes if present in surface material.

An indication of the utility of the soil/sediment adsorption coefficient is provided by the following expression:

$$V_c = V_{GW} / (1 + \frac{B}{\theta} f_{oc} K_{oc})$$

where:

- V_c = velocity of a given contaminant relative to the interstitial pore velocity of groundwater
- V_{GW} = interstitial pore velocity of groundwater
- B = soil bulk density
- r = specific yield (porosity) of soil matrix
- f_{oc} = fraction of organic carbon in the soil matrix
- K_{oc} = soil/sediment adsorption coefficient

From the expression, it can be seen that the mobility (velocity) of a chemical contaminant, relative to groundwater seepage velocity, is inversely proportional to its soil/sediment adsorption coefficient and the fractional organic carbon content of the soil. The greater the adsorption coefficient and soil organic carbon content, the slower the chemical will migrate through both the saturated and unsaturated zones.

- The "mobility index" is the logarithm of the ratio of (vapor pressure) (water solubility)/(soil/sediment adsorption coefficient). This parameter was proposed by Ford and Gurba as a means of inferring the relative mobilities of various chemicals in the environmental domain (Ford and Gurba, 1983). The greater the value of the mobility index, the more mobile the chemical.

4.0 HYDROGEOLOGIC INVESTIGATION

4.1 OBJECTIVES OF INVESTIGATION

4.1.1 Surface Soils

As much as 3 feet of surface soil at the site had been removed as part of the initial remedial action. This material was replaced with coarse gravel fill. The purpose of the surface soil investigation was to determine if all the contaminated soil had been removed from the site. The investigation concentrated on the first 2 feet of soil below the new gravel fill. Sampling was also conducted to determine if contamination had migrated upward into the new gravel fill.

4.1.2 Subsurface Soils

The purpose of the subsurface investigation was to determine if soil had been contaminated at depth, and if so to define vertical zones of contamination. The investigation was also conducted to define the site subsurface geology.

4.1.3 Groundwater

The purpose of the groundwater investigation was to determine whether groundwater contamination existed on site, and if so to determine if contaminated groundwater flowed off site. The investigation attempted to determine groundwater flowrates and directions, the effects of daily and monthly tidal fluctuations on the groundwater, and the hydraulic properties of the subsurface materials.

4.2 REGIONAL SETTING

4.2.1 Physiography

The Chemical Control Site is located in Union County, which is in the Piedmont physiographic province. The site lies along the Elizabeth River near its confluence with the Arthur Kill. The site is in a highly industrial area with an essentially flat topography.

4.2.2 Soils

The soil in the vicinity of the site was described in a soil survey of Union County as a "soil of tidal marsh origin, composed of silts and clays deposited during the recessional period of the Wisconsin glaciation. The top two feet consists of an organic layer of decomposed roots from tidal marsh plant growth" (Rogers, 1952).

This soil type has a low permeability due to the high silt and clay content. It occurs near the coast along the Arthur Kill and in the Newark area. The soil is frequently covered with

fill to raise the areas where it occurs above the maximum sea level, thus reclaiming land for commercial usage.

4.2.3 Geology

The bedrock below the site is the Brunswick Formation, part of the Newark Group of sediments deposited in the Newark Basin during the Triassic Period. The Newark Group consists of 16,000 to 20,000 feet of non-marine clastics, with some intrusive and extrusive basic igneous rocks. The Brunswick Formation is the thickest of three formations comprising the Newark Group. In the Newark area this formation is estimated to be 6,000 feet thick. One well on record in the Newark area was still in the Brunswick Formation at a depth of 2,600 feet (Herpers, 1951).

In the vicinity of the site the Brunswick is characterized as a fine-grained shale to siltstone. It has a characteristic red color. The regional strike is N 50:E, dipping 9-13:N. Figure 4-1 shows the depth to the top of the Brunswick in the vicinity of the site.

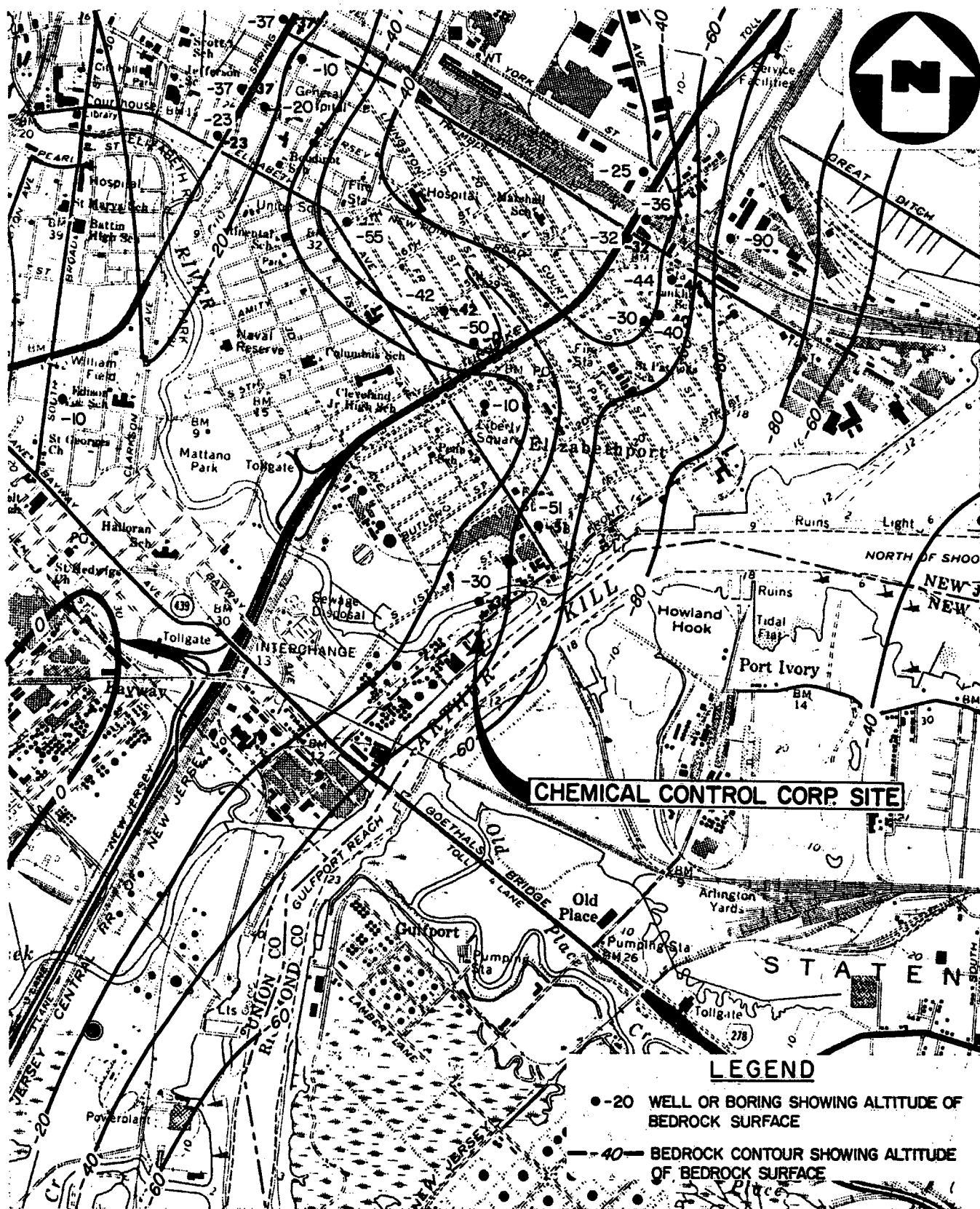
The Brunswick Formation is overlain throughout most of Union County by Pleistocene glacial deposits from the Wisconsin glaciation. These glacial deposits are found in varying thicknesses, at some locations filling pre-glacial valleys with stratified outwash deposits. Unstratified glacial drift forms a mantle over the Brunswick Formation throughout most of Union County. Figure 4-2 presents a map showing the thickness of Pleistocene glacial deposits near the site.

The recent depositional history is from overbank stream deposits formed after the glacial retreat. Mud and silts with inclusions or organic materials are common in the Newark area and along the Arthur Kill as described previously. Following this deposition, much low-lying land has been reclaimed and built up with artificial fill.

4.2.4 Groundwater

The majority of the groundwater used in Union County is derived from the Brunswick Formation. Groundwater is produced primarily from joints and fractures which decrease with depth. Major fracture trends are N45:E and N75:W, both with approximately vertical dips. These fractures can provide a directional movement of groundwater under pumping and also a directional movement of contaminants as established in other studies (Spayd, 1985). Figures 4-1 and 4-2 show the locations of some wells close to the Chemical Control property developed in the Brunswick Formation.

The Pleistocene glacial deposits are important sources of groundwater locally. In some areas thick stratified outwash deposits of well-sorted sands and gravels fill pre-glacial

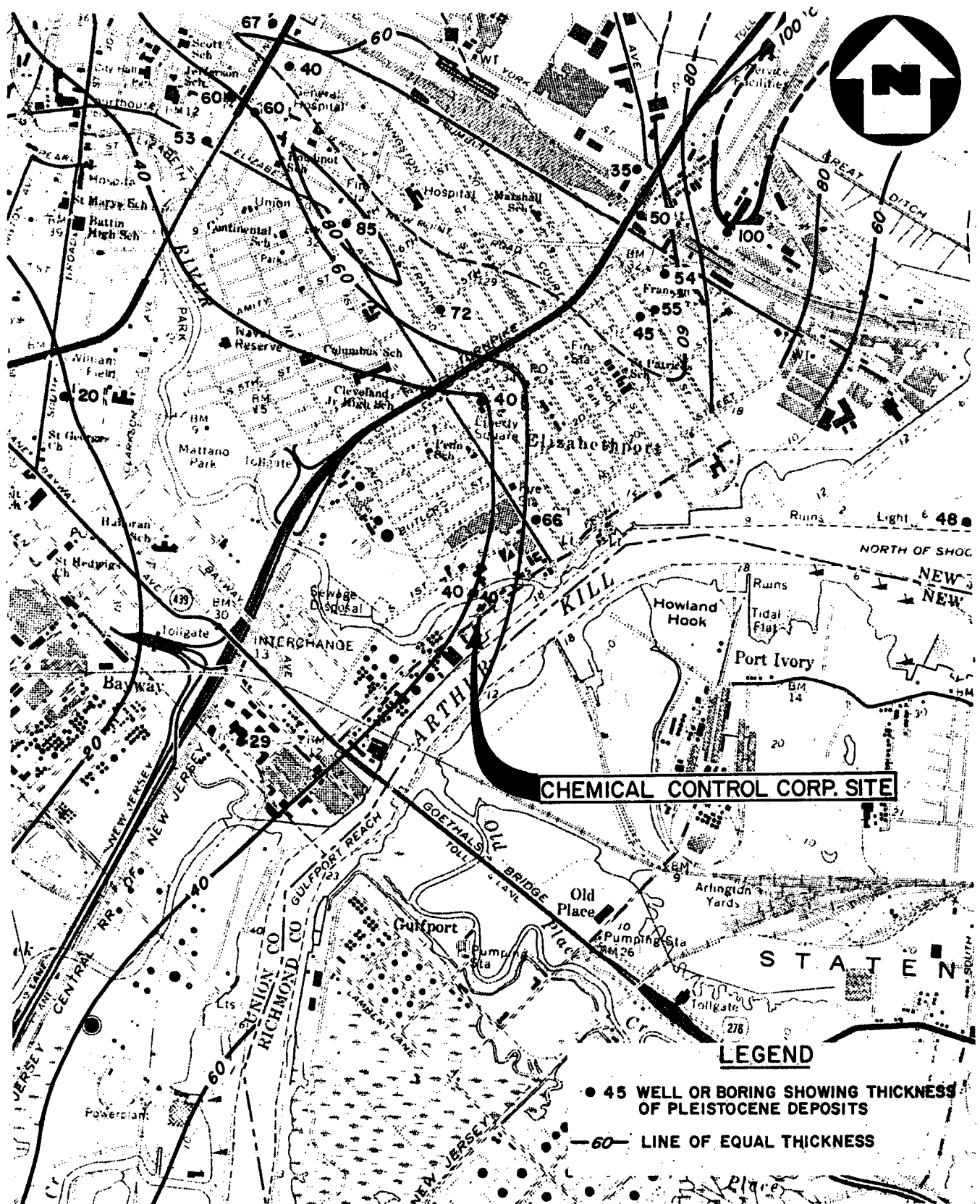


BASE MAP IS A PORTION OF BEDROCK TOPOGRAPHY AND THICKNESS OF PLEISTOCENE DEPOSITS IN UNION COUNTY AND ADJACENT AREAS, NEW JERSEY BY BRONIUS NEMICKAS, 1974.

FIGURE 4-1

BEDROCK CONTOUR MAP
CHEMICAL CONTROL CORP. SITE, ELIZABETH, N.J
 SCALE: 1" = 2000'





BASE MAP IS A PORTION OF BEDROCK TOPOGRAPHY AND THICKNESS OF PLEISTOCENE DEPOSITS IN UNION COUNTY AND ADJACENT AREAS, NEW JERSEY BY BRONIUS NEMICKAS, 1974.

FIGURE 4-2

**THICKNESS OF PLEISTOCENE DEPOSITS
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ**

SCALE: 1"=2000'



valleys which had been cut into the Brunswick Formation. These deposits can provide sufficient supplies of groundwater for industrial purposes. However throughout most of the county the glacial deposits form a thin covering over the Brunswick and are sufficiently fine-grained to be of little importance for groundwater development. In some instances the deposits act as a confining layer to the Brunswick Formation.

4.3 SURFACE AND NEAR SURFACE SOIL INVESTIGATION (NEW AND OLD FILL)

4.3.1 Methods of Investigation

Surface soil samples were taken at twenty locations. Ten of these locations are on the Chemical Control property where large numbers of drums had been stored during the operation of the facility. Ten locations are off site in front of the Loizeaux Concrete property where waste was staged during the initial site cleanup. The locations of the soil sampling points are presented in Figure 4-3.

The onsite soil sampling was conducted by taking a composite sample of the new gravel fill, which was three feet thick in most cases. Samples of the material below the new fill were obtained where possible. The water table was high at the time of sampling and therefore samples at depth were often not obtained.

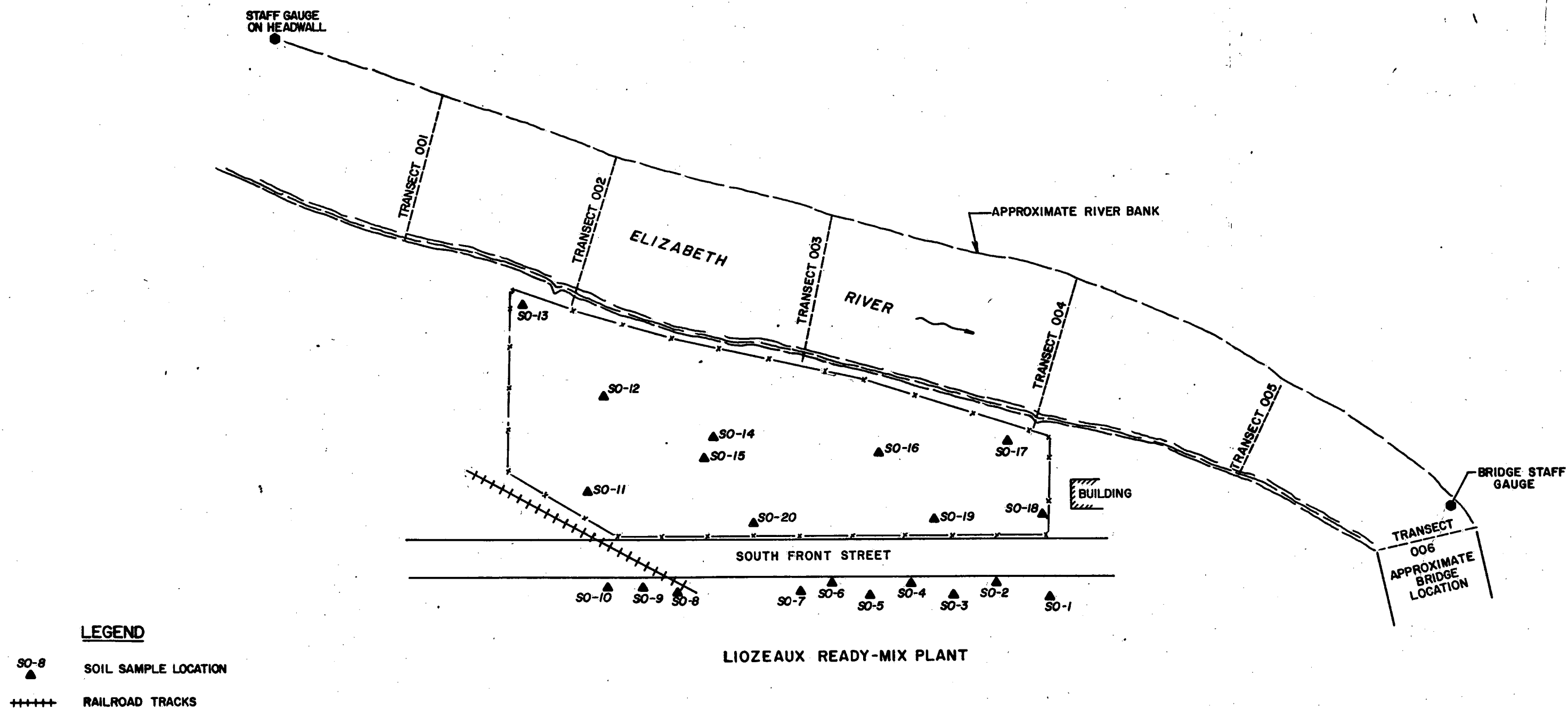
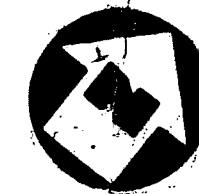
The offsite soil samples are composites of the top 3 to 4 feet of material. Samples were obtained with stainless steel power augers, advanced as far as practical at each location. One composite analysis was obtained from each offsite sampling location.

All surface soil samples were submitted for full HSL analyses. These results are presented in Appendix A.

4.3.2 Results of Investigation - Physical System

No natural surface soil was found onsite or offsite. The material immediately below the top 3 feet of coarse gravel onsite is a black silty sand to gravel fill with building rubble fragments. Offsite the upper soil is a coarse gravel up to 1 foot thick which is underlain by fill materials.

The marsh deposits of silt and clay described in the literature were found from 9 to 11 feet below the ground surface during the subsurface drilling. Therefore the soil conditions described in the literature were consistent with what was found at the site. The uppermost material is fill, which overlies the natural deposits.



**LOCATION OF SURFACE SOILS SAMPLING POINTS
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ**

FIGURE 4-3



4.3.3 Results of Investigation - Extent of Contamination

4.3.3.1 Results of Onsite Surface and Near-Surface Soil Investigation (New and Old Fill)

Figure 4-4 summarizes the analytical results for samples obtained onsite. Included on the figure are total concentrations for each of the following classes of chemicals: polynuclear aromatic hydrocarbons (PAHs); polychlorinated biphenyls (PCBs); monocyclic aromatics (e.g., benzene and benzene derivatives such as toluene); halogenated aliphatic hydrocarbons (e.g., tetrachloroethene, trichloroethene, and methylene chloride); phthalate esters (e.g., bis(2-ethylhexyl)phthalate, butylbenzylphthalate); and chlorinated benzenes (e.g., 1,2-dichlorobenzene).

The analytical results for most of the new gravel fill samples indicate that organic HSL chemicals are either not present or are present at relatively low concentrations. Several notable exceptions are evident in this regard, however. The new gravel fill sample collected at sampling point SO-17 contains PCBs at a concentration of 23,000 ug/kg. The sample obtained at location SO-11 also contains PCBs, although at a lower concentration (340 ug/kg). The sample from location SO-20 contained PCBs (280 ug/kg), as well as PAHs (874 ug/kg), phthalate esters (970 ug/kg), and chlorinated benzenes (380 ug/kg). Several volatile chemicals were also identified in this sample, although at much lower levels.

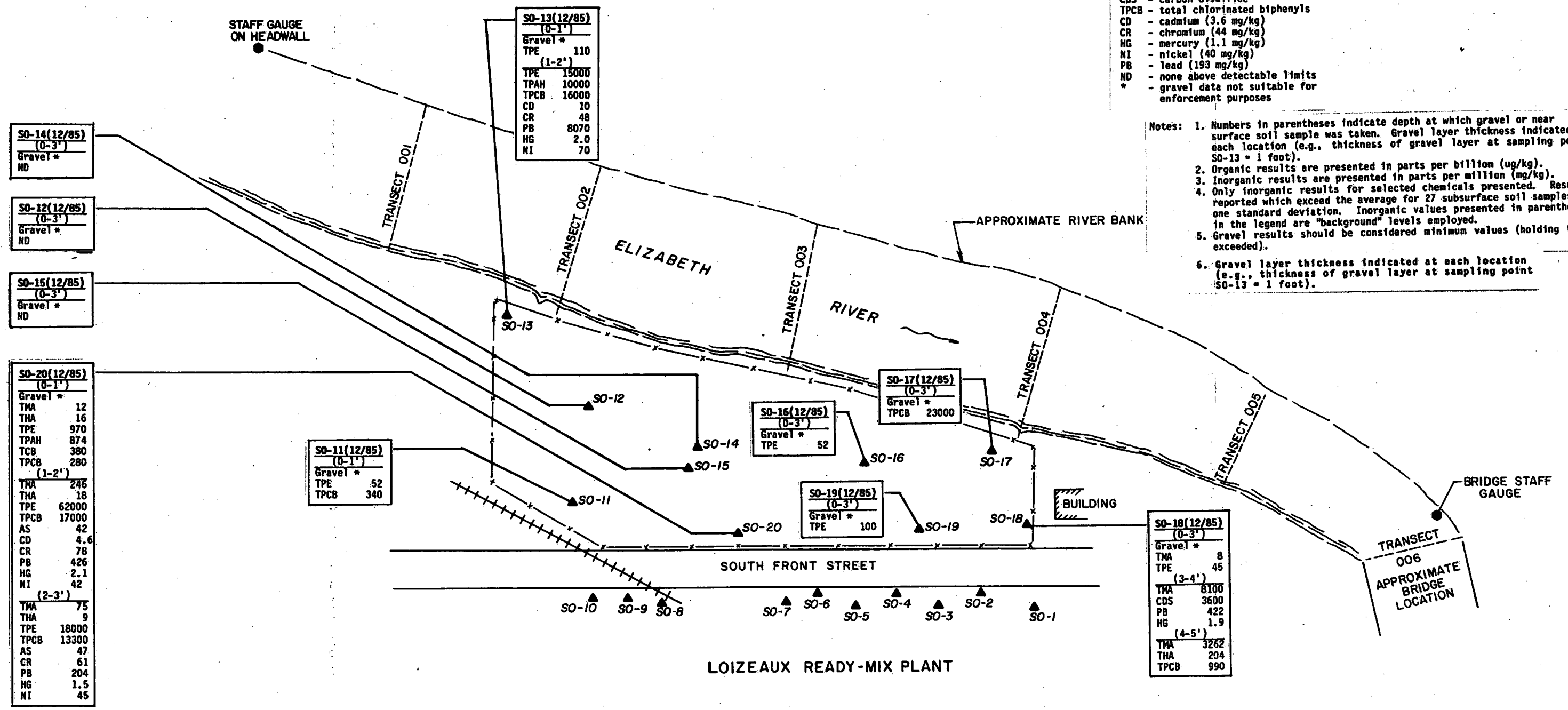
In addition, it should be noted that the analytical results for the gravel samples were rejected by EPA Region II validation personnel (holding time exceeded). Positive findings have been retained in the data base, although these data may not be used for enforcement purposes. Negative findings (such as those for most of the volatile chemicals) in the gravel samples cannot be used as conclusive evidence of the lack of contamination. Positive results should be considered minimum values in view of holding time exceedance. The results for the old fill samples provide some indication of volatile contamination near the surface of the site, however only relatively low levels were found in these samples. It is believed that the newly placed gravel fill is not contaminated with volatile chemicals.

It is considered probable that the presence of contaminants in the new gravel fill samples is a direct result of the composite sampling practice. The same chemicals were detected in the old fill material (Figure 4-4) and the subsurface soil (Section 4.4.3). Samples from the base of the new gravel fill undoubtedly contain contaminants as a result of direct contact with contaminated material. The uppermost old fill sample obtained at location SO-20 contained PCBs at a concentration of 17,000 ug/kg, a fact which provides support for this supposition. Any new gravel fill in contact with this soil is

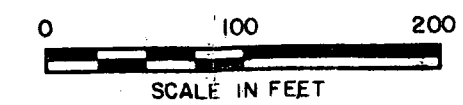


- LEGEND**
- TMA - total monocyclic aromatics
 - THA - total halogenated aliphatics
 - TPE - total phthalate esters
 - TPAH - total polynuclear aromatics
 - TCB - total chlorinated benzenes
 - CDS - carbon disulfide
 - TPCB - total chlorinated biphenyls
 - CD - cadmium (3.6 mg/kg)
 - CR - chromium (44 mg/kg)
 - HG - mercury (1.1 mg/kg)
 - NI - nickel (40 mg/kg)
 - PB - lead (193 mg/kg)
 - ND - none above detectable limits
 - * - gravel data not suitable for enforcement purposes

- Notes:**
1. Numbers in parentheses indicate depth at which gravel or near surface soil sample was taken. Gravel layer thickness indicated at each location (e.g., thickness of gravel layer at sampling point SO-13 = 1 foot).
 2. Organic results are presented in parts per billion (ug/kg).
 3. Inorganic results are presented in parts per million (mg/kg). Results reported which exceed the average for 27 subsurface soil samples by one standard deviation. Inorganic values presented in parentheses in the legend are "background" levels employed.
 4. Only inorganic results for selected chemicals presented.
 5. Gravel results should be considered minimum values (holding time exceeded).
 6. Gravel layer thickness indicated at each location (e.g., thickness of gravel layer at sampling point SO-13 = 1 foot).



ANALYTICAL RESULTS-NEAR SURFACE SOIL AND GRAVEL SAMPLES (ONSITE)
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ



also undoubtedly contaminated because of the adherence of old fill particles. The new gravel fill is presumed to be clean on the surface of the site, since no contact with the underlying old fill is possible. The new fill was brought to the site after disposal/storage operations ceased. Note that the new gravel fill is only 1 foot thick at some sampling locations (e.g., SO-11, SO-13, SO-20).

As shown on Figure 4-4, the organic chemicals detected in the new gravel fill samples were generally identified in the old fill samples at higher concentrations. High concentrations of the relatively immobile PCBs, PAHs, and phthalate esters were detected in the old fill samples. At locations where more than one sample of the old fill was collected (e.g., sampling points SO-18 and SO-20), the concentrations of the organic contaminants tend to decrease with depth.

Also included on Figure 4-4 are results for selected inorganic chemicals. Inorganic analytes are normally found at background concentrations in natural soil. Because adequate background samples could not be obtained in this highly industrialized area, the statistical information provided with the analytical results in Appendix A was used to identify inorganic concentrations that may indicate residual contamination. Several of the inorganic analytes were focused on in this respect, primarily because of their documented adverse human health or environmental effects. These include the following: arsenic; cadmium; chromium; lead; mercury; and nickel.

The inorganic results presented in Figure 4-4 include detections of the above chemicals that exceed the average value for 27 subsurface soil samples (Section 4.4.3) by at least one standard deviation. The values calculated from the available inorganic soil data are included on Figure 4-4. Statistical summary sheets and calculations are presented in Appendix A.

Inorganic substances were detected at high concentrations in several of the uppermost old fill samples, particularly at sampling point SO-13. Cadmium (10 mg/kg), chromium (48 mg/kg), lead (8070 mg/kg), mercury (2 mg/kg), and nickel (70 mg/kg) were detected in this sample at concentrations that exceeded the established "background" criteria.

Based on the analytical results it is apparent that residual contamination exists in the uppermost old fill material. The most concentrated chemicals are the PAHs, PCBs, phthalate esters, and various inorganic analytes. Although volatile organic chemicals were also detected, they are present at much lower concentrations.

The new gravel fill overlying the old fill appears to be relatively clean in comparison, although some samples contained PCBs, etc. It is not believed that the chemicals in the new

gravel fill are present near the ground surface. Rather, these results reflect contact points with the underlying contaminated material (old fill) and the composite sampling technique. Although the negative results for these samples are not valid data, no disposal of chemicals has occurred since the gravel was placed on the site. Thus it is not believed that volatile chemicals (in particular) are present on the surface of the site.

4.3.3.2 Results of Drum-Staging Area Investigation *

The surface of the former drum staging area consists of approximately 1 foot of clean gravel. As previously discussed, a composite of the top 3 to 4 feet of material was obtained and shipped to EPA contract laboratories for analysis.

Samples of the old fill from the former drum-staging area contain various volatile, base/neutral extractable, and pesticide fraction organic chemicals. Figure 4-5 summarizes the analytical results for these samples. Included on Figure 4-5 are total concentrations for the various classes of chemicals detected, including the following: PAHs; PCB; monocyclic aromatics; and halogenated aliphatic hydrocarbons.

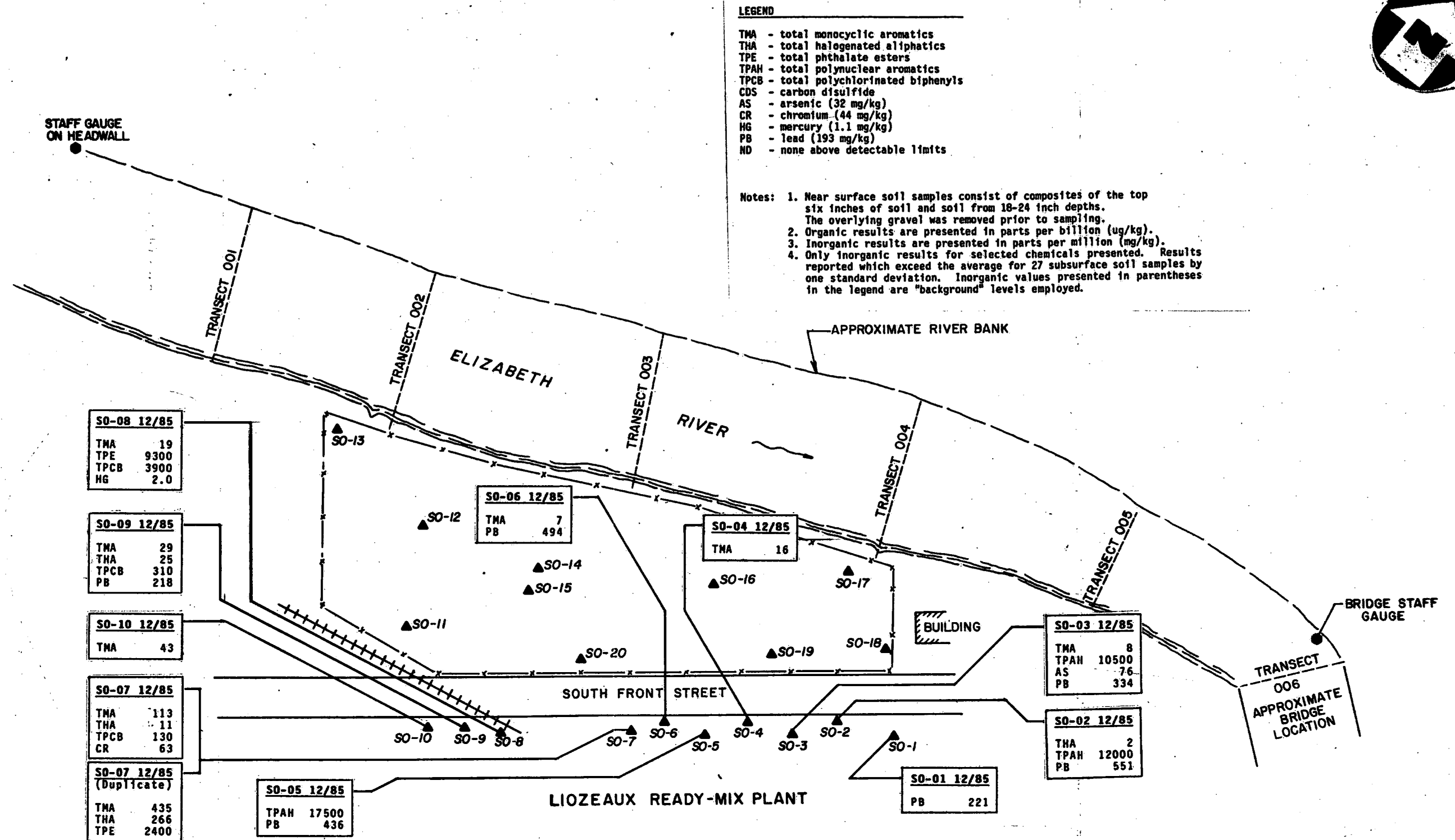
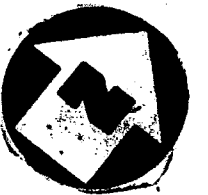
Figure 4-5 also presents results for selected inorganic chemicals. Inorganic chemicals were selected for inclusion using the same rationale as discussed in the preceding section. Arsenic, chromium, and mercury exceeded the statistical criteria in one sample each. Contamination with these substances is not pervasive throughout the former drum-staging area. Lead was detected at relatively high concentrations (maximum concentration = 551 mg/kg) in a number of the samples (6 of 11) as shown on Figure 4-5, however.

It is apparent that residual contamination associated with the staging operation remains in this area. The most concentrated contaminants detected in the near surface soil samples include the PAHs, PCBs, phthlate esters, and lead.

4.4.3.3 Results of Offsite Sampling

Five surface soil samples were collected from offsite locations in May 1986. Complete analytical results for these samples are included in Appendix A. Four samples were collected west of the site and one sample was collected east of the site. Sampling locations are provided on Figure A-1 (Appendix A).

1,1,1-trichloroethane was detected in four of the offsite surface soils amples. Concentrations ranged from 11 to 12 ug/kg. Numerous polynuclear aromatic hydrocarbons were also identified in offsite surface soil samples. Total polynuclear aromatic hydrocarbon concentrations ranged to 19,500 ug/kg (Sample CC-SO-111). Various polychlorinated biphenyls (Aroclor 1254 and Aroclor 1260) were also detected in offsite



ANALYTICAL RESULTS-NEAR SURFACE SOIL SAMPLES (DRUM STAGING AREA)
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ



FIGURE 4-5

samples. Concentrations of PCBs in offsite soil samples (adjacent to the upstream junkyard) ranged to 5,900 ug/kg. While it is possible that this polynuclear aromatic hydrocarbon and polychlorinated biphenyl contamination was introduced to the upstream area as a result of flooding or the firefighting operations, it is considered equally as likely that these substances are present as a result of operations at the junkyard. Soil at the junkyard is stained and this area is also a possible source of environmental contamination.

4.4 SUBSURFACE SOIL INVESTIGATION

4.4.1 Methods of Investigation

The subsurface soil was investigated by taking split-barrel samples and observing drill cuttings as the drilling of ten monitoring wells progressed. The split-barrel samples were screened for volatile organic vapors either as the samples were removed from the sampler or after the samples were placed in glass jars and vapors were allowed to accumulate in the head spaces. A portion of each sample was reserved for geologic description while the remainder was mixed and sent to CLP for full HSL analysis.

The borehole geology logs for the ten monitoring wells are presented in Appendix C. The locations of the monitoring wells are shown in Figure 4-6. Geologic cross-sections are presented in Figures 4-7 and 4-8. Complete tabulations of the analytical results are presented in Appendix A.

4.4.2 Results of Investigation - Physical System

The top 3 feet of material on site consists of coarse gravel fill described previously. Below this is the black silty sand to gravel fill which was probably emplaced to raise the elevation of the land surface for industrial purposes. Occasionally the black fill had inclusions of a red silty fill, apparently derived from the glacial drift. The fill material frequently yielded high head space readings and an oil film was observed on it in some of the boreholes.

The fill is underlain by silt and clay similar to the material described in the literature as the natural soil for the area. This material frequently has roots and inclusions of other organic material, most commonly within the first 2 feet. Only two of the boreholes completely penetrated this horizon. In MW-001 it is 11 feet thick while in MW-007 it is 19 feet thick. In the remainder of the boreholes the

drilling was stopped at the base of the fill and a final split-barrel sample was advanced 2 feet into the silt and clay. This material was found in all of the boreholes, even those that were drilled offsite.

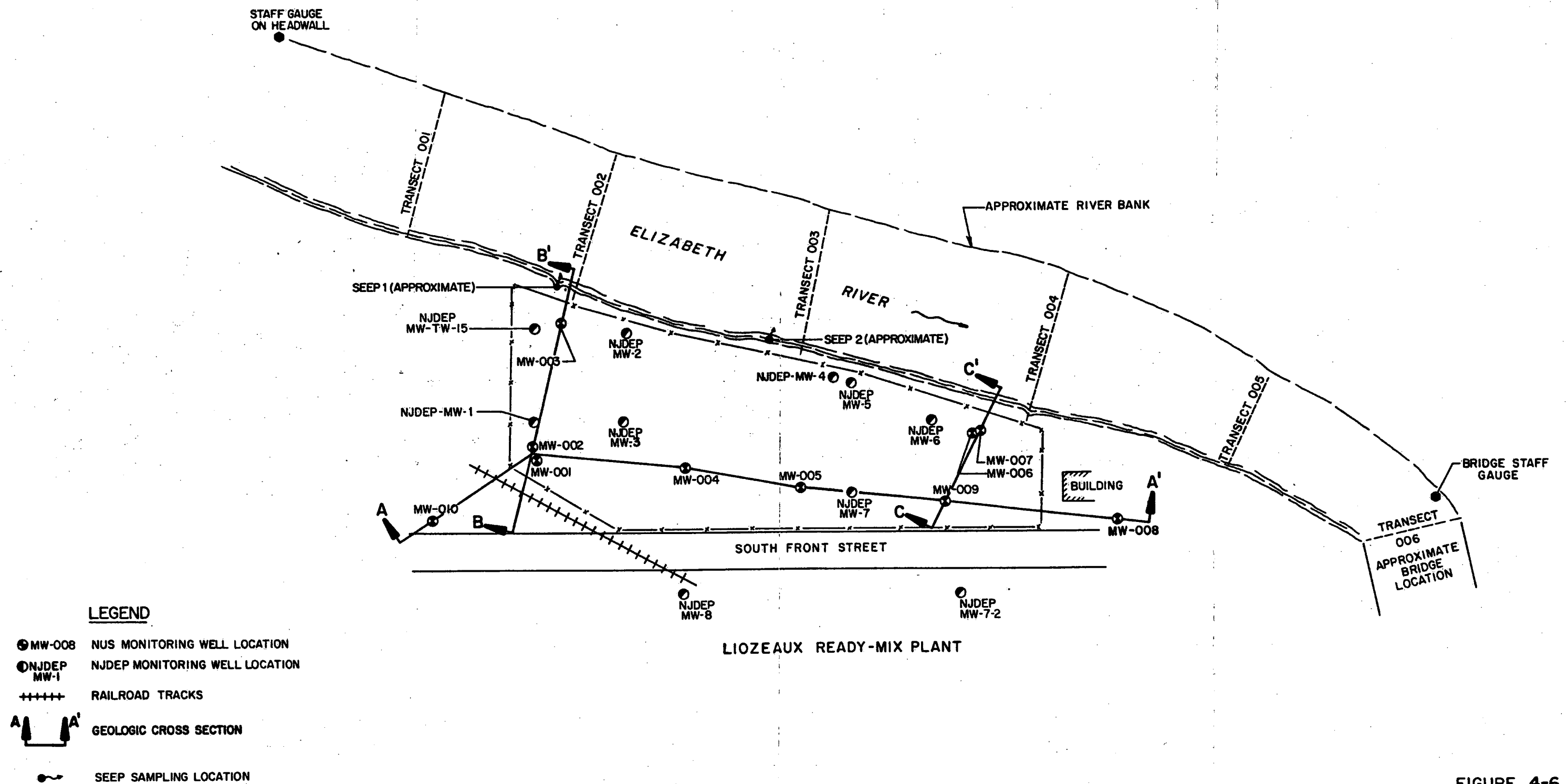
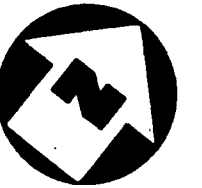
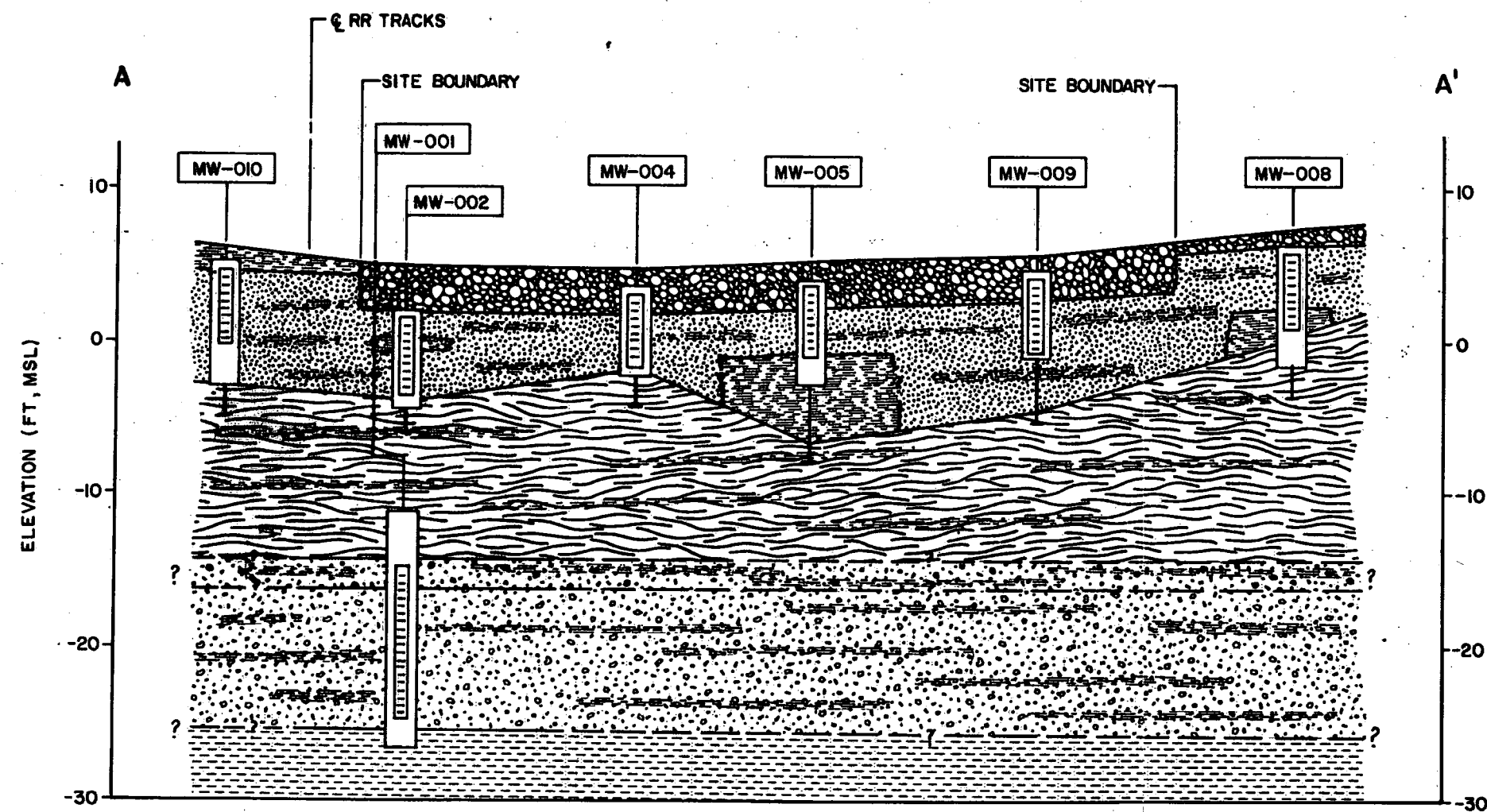


FIGURE 4-6



NOTE: GEOLOGIC CONTACTS DASHED WHERE APPROXIMATE OR INFERRED.

GEOLOGIC CROSS SECTION A-A'
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ

ERA	SYSTEM	FORMATION
CENOZOIC	QUATERNARY	NEW FILL - CLEAN COARSE GRAVEL
		OLD FILL - SILTY SAND TO GRAVEL
		OLD FILL - RED SILT
		SILTY CLAY TO CLAYEY SILT
MESOZOIC	PLEISTOCENE	GLACIAL TILL - GRAY SILTY SAND TO SANDY SILT
		GLACIAL TILL - RED SILTY SAND TO SANDY SILT
		BEDROCK
	TRIASSIC	BRUNSWICK

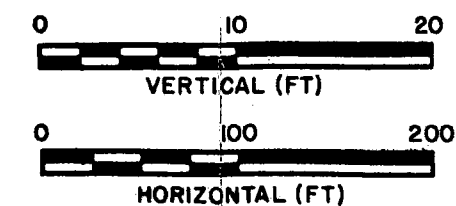


FIGURE 4-7

Pleistocene glacial deposits underlie the silt and clay. The glacial material is characterized by a thin grey silty sand to sandy silt at the top followed by a stiff red sandy silt to silty sand with some small rock fragments. The grey till was wet while the red till was slightly moist. The red till is apparently derived from the underlying Brunswick Formation based on its color and fine texture. Based on the regional information this material probably represents ground moraine deposition from underneath the ice sheet.

The Brunswick Formation is characterized as a red shale to siltstone, slightly moist to dry. It resembles the above-lying glacial deposits and was differentiated on the basis of auger refusal and texture.

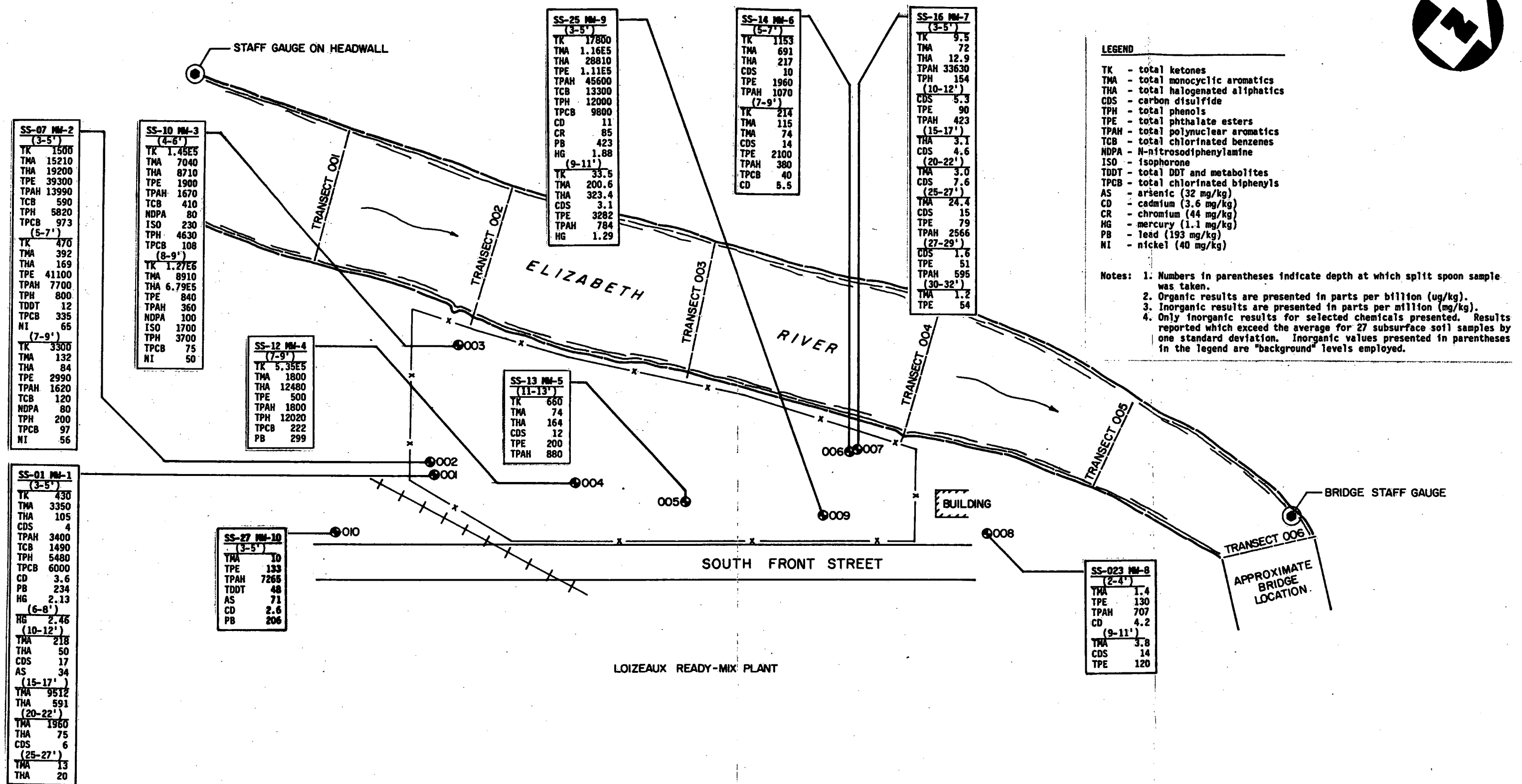
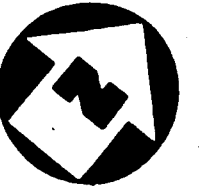
Drilling proceeded to the Brunswick in MW-001 and MW-007. The cross-sections shown in Figure 4-8 indicate that the top of the Brunswick is at the -25 foot elevation in MW-001 and at the -34 foot elevation in MW-007. The elevation of the glacial-bedrock contact is not shown with certainty in the cross-sections because of the uncertainty of its elevation between these two holes.

4.4.3 Results of Investigation - Extent of Contamination

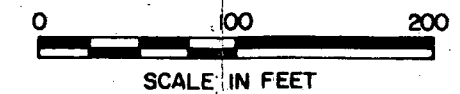
Figure 4-9 summarizes the occurrence and distribution of subsurface soil contaminants. Included on the figure are total concentrations for the following chemical classes: ketones; monocyclic aromatics; halogenated aliphatics; phthalate esters; PAHs; chlorinated benzenes; phenols; PCBs; and miscellaneous chemicals (i.e., carbon disulfide, N-nitrosodiphenylamine, and isophorone). Detections of arsenic, cadmium, chromium, lead, mercury, and nickel above the upper bound of the 67 percent confidence interval (Section 4.3.3) are also included. Sampling depths at each location are specified on Figure 4-9.

Organic HSL chemicals were detected in all of the subsurface soil samples. Inorganic chemicals were also detected at relatively high concentrations in a number of the samples.

Figure 4-9 reveals that although all of the subsurface soil samples appear contaminated, several display markedly higher contaminant concentrations. Samples from well borings for monitoring wells MW-001, 002, 003, 004 and 009, in particular, contained relatively high levels of organic chemicals. Concentrations of ketones, halogenated aliphatics and phthalate esters range to approximately 100,000 to 1,000,000 µg/kg (ppb) in some of these samples. Based on these results it appears that extensive subsurface soil contamination is present in the southwestern portion of the site (near MW-001 and MW-003), and locally in the vicinity of MW-009.



ANALYTICAL RESULTS-SUBSURFACE SOIL SAMPLES
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ



In contrast to the near-surface (uppermost old fill) samples (Section 4.3.3), volatile organic chemicals appear to be much more concentrated and pervasive in the deeper subsurface soil and old fill. As discussed in Section 3.0, the volatile organics (and to a slight degree, the phthalate esters) are more water soluble and less soil-adsorptive than the PCBs, PAHs, and other base/neutral extractable compounds. The presence of high concentrations of the volatiles (particularly in the deeper samples) is probably attributable to leachate generation and percolation through the soil horizon. Although PCBs, PAHs and other less hydrologically mobile chemicals were detected in the subsurface media, concentrations of these analytes are lower than in the near-surface material. From Figure 4-9 it can be seen that concentrations of these substance generally decrease with depth.

The data indicate that organic chemicals may have moved into and through the underlying silt and clay layer. The samples obtained at depths of 10-12 feet and 15-17 feet (monitoring well boring MW-001) contain volatile organic chemicals. These samples were collected in the silt and clay marsh deposit. The samples obtained below these (20-22') and (25-27') were retrieved from the underlying glacial till and indicate that contaminants may have moved through the silt and clay layer. Levels of organic chemicals are generally much lower in the deeper sampels. The data do not indicate a clear-cut trend of downward migration. As an example, monocyclic aromatic chemicals were detected at low concentrations in the intermediate depth samples, but were noted to increase again at depth. It is considered possible that some cross-contamination was introduced during the drilling program.

In conclusion, contamination appears most pronounced in subsurface material (deep old fill and natural soil) at depths of approximately 3 to 10 feet. Volatile organics, phenolic compounds, phthalate esters, and PAHs are present at the highest concentrations in the subsurface soil samples. PCBs, isolated pesticides and some miscellaneous chemicals were detected at relatively low concentrations. Inorganic chemicals were identified at concentrations in excess of established background levels in the subsurface soil samples. An indication that chemicals have migrated through the silt and clay layer was provided by the data.

4.5 GROUNDWATER INVESTIGATION

4.5.1 Methods of Investigation

The groundwater was investigated by installing eight shallow and two deep monitoring wells, by measuring the water levels of these wells and of 10 wells previously installed by the NJDEP, by conducting slug tests and a short term pumping test, and by measuring the tidal fluctuations of the Elizabeth River. Well construction sheets are presented in Appendix C, with slug test

and pumping test results presented in Appendix D. Groundwater flow calculations are presented in Appendix B. Table 4-1 presents a summary of well depths and screened intervals.

The shallow monitoring wells are screened within the fill on top of the silt and clay. Four of these wells, MW-002, MW-003, MW-006, and MW-009 are located inside the perimeter of the site. Two of these wells, MW-004 and MW-005, are located in the center of the site. The remaining two shallow wells, MW-008 and MW-010, were placed offsite to assess the possible offsite migration of contaminants.

Two deep wells, MW-001 and MW-007, were installed to assess vertical groundwater gradients. The wells were installed as clusters with two of the shallow monitoring wells, MW-002 and MW-006 respectively. MW-001 was used to obtain groundwater levels and samples while MW-007 was used to obtain groundwater levels only.

All wells were drilled with hollow stem augers. Shallow wells were installed by augering to the base of the fill and setting the screen at the desired depth through the auger stems. The augers were pulled back as a sand pack was added until the sand extended approximately 1 foot above the top of the screen. Bentonite pellets were then used to establish the surface seal, covered by grout. The screens in the shallow wells were set as high as practical at each location in order to screen the top of the water table. The deep wells were installed by augering to refusal in the bedrock and setting the screens in the glacial material on top of bedrock. A sand pack extending approximately 3 feet above the screen was emplaced as the augers were pulled back. Approximately 3 feet of bentonite pellets were then used to establish a seal. The remainder of the annulus was grouted by the tremie pipe method.

Stevens water level recorders were installed on monitoring wells MW-001, MW-002, and MW-003. These recorders provided continuous water level records from December 12, 1985 to January 15, 1986. The recording charts were changed weekly throughout this time. Figure 4-10 presents these water level records.

Periodic water level measurements were taken throughout the study. Measurements were taken on all of the NUS wells and on 10 monitoring wells previously installed by the NJDEP. The depths of the NJDEP wells were determined at the beginning of the study. Water levels were measured daily at the beginning of the study, weekly as the study progressed, and six times over a two-day period in January to define water level fluctuations attributable to the monthly high tide. Table 4-2 presents the water level measurements.

Tidal information on the Elizabeth River was obtained by measuring the river stage at two points shown in Figures 4-3 and 4-6. The upstream point is a concrete headwall along the

TABLE 4-1

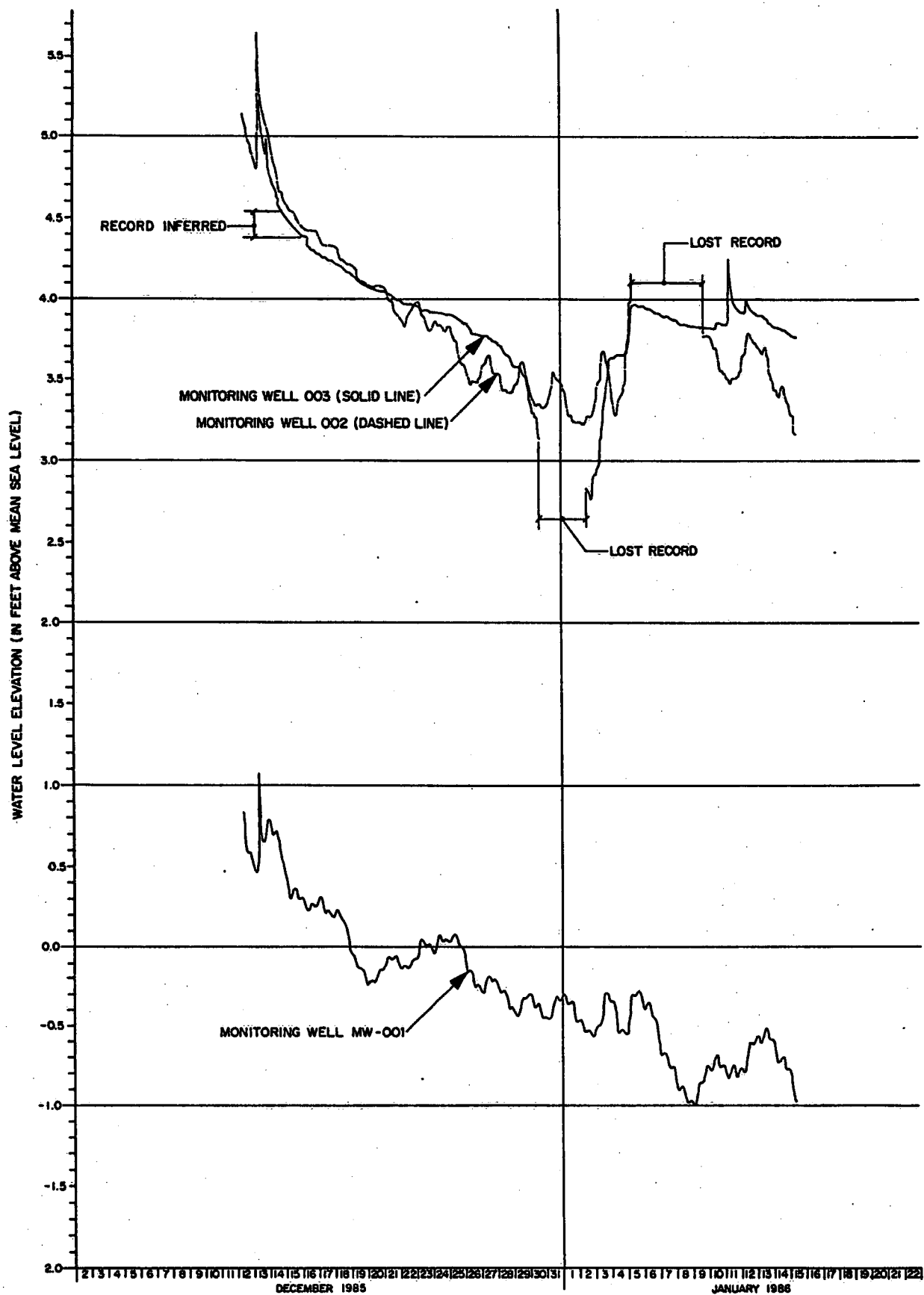
**MONITORING WELL CONSTRUCTION
CHEMICAL CONTROL CORPORATION SITE**

Well	Type ¹	Reference Elevation (Ft, MSL)	Ground Elevation (Ft, MSL)	Zone Screened	Well Depth (Ft, BGS) ²	Screen Elevation	
						Top (Ft, MSL)	Bottom (Ft, MSL)
NUS Wells							
MW-001	SS	6.43	4.89	Deep	31.50	-14.71	-24.71
MW-007	PVC	6.81	5.44	Deep	40.00	-20.76	-30.76
MW-002	SS	6.44	4.76	Shallow	9.50	1.26	-3.74
MW-003	SS	7.30	5.19	Shallow	7.50	3.69	-1.31
MW-004	SS	5.95	4.71	Shallow	7.00	3.21	-1.79
MW-005	SS	6.58	5.24	Shallow	11.00	3.94	-1.06
MW-006	SS	6.48	5.83	Shallow	8.00	3.83	-1.17
MW-008	SS	7.12	7.12	Shallow	9.00	5.72	0.72
MW-009	SS	7.26	5.74	Shallow	9.00	4.34	-0.66
MW-010	SS	5.93	6.15	Shallow	9.00	4.65	-0.35
NJDEP Wells							
NJDEP #1	PVC	6.40	4.86	Shallow	7.40	NA	NA
NJDEP #2	PVC	7.29	5.52	Shallow	8.06	NA	NA
NJDEP #3	PVC	6.65	5.00	Shallow	8.91	NA	NA
NJDEP #4	PVC	9.96	5.94	Shallow	7.74	NA	NA
NJDEP #5	PVC	9.31	5.87	Shallow	8.43	NA	NA
NJDEP #6	PVC	7.53	5.93	Shallow	9.10	NA	NA
NJDEP #7	PVC	7.07	6.50	Shallow	7.30	NA	NA
NJDEP #7-2	PVC	6.91	5.20	Shallow	NA	NA	NA
NJDEP #8	PVC	8.87	6.71	Shallow	6.39	NA	NA
NJDEP TW-15	PVC	8.96	5.11	Shallow	8.70	NA	NA

¹SS = Stainless Steel

²FT, BGS = Feet below ground surface

NA = Not Available



WATER LEVEL RECORD
CHEMICAL CONTROL CORP SITE, ELIZABETH, NJ

FIGURE 4-10



TABLE 4-2

WATER LEVEL MEASUREMENTS
CHEMICAL CONTROL SITE

	NUS Wells										NJDEP Wells										Staff Gauge	River Concre Headwa
	MW-001	MW-002	MW-003	MW-004	MW-005	MW-006	MW-007	MW-008	MW-009	MW-010	#1	#2	#3	#4	#5	#6	#7	#8	#7-2	TW-15		
Reference El.	6.43	6.44	7.30	5.95	6.58	6.48	6.81	7.12	7.26	9.93	6.40	7.29	6.65	9.96	9.31	7.53	7.07	6.91	6.87	8.96	10.66	5.58
Ground El.	4.89	4.76	5.19	4.71	5.24	5.83	5.44	7.12	5.74	6.15	4.86	5.52	5.00	5.94	5.87	5.93	6.60	5.20	6.71	5.11	--	--
Date Measured	Water Surface Elevations																					
12/04/85	1.10	4.28	4.20	4.27	3.81	2.79	0.58	3.51	3.28	4.46	--	--	--	--	--	--	--	--	--	--	--	--
12/05/86	0.64	4.26	4.19	4.19	3.77	2.75	0.38	3.39	3.18	4.34	4.15	3.84	4.15	3.56	4.03	4.17	--	3.01	3.88	4.16	3.04	3.12
12/06/85	0.86	4.15	4.14	4.16	3.78	2.88	0.77	3.37	3.28	4.29	4.19	3.77	4.15	3.52	3.84	3.95	3.81	2.87	3.71	4.10	-0.64	-0.49
12/11/85	0.48	4.33	4.40	4.19	3.62	3.71	1.02	3.60	3.63	4.04	4.34	4.44	4.20	3.65	3.74	3.53	--	2.97	3.60	4.26	2.12	1.86
12/12/85	0.83	5.14	5.35	5.15	4.29	4.02	1.34	4.35	5.11	4.30	5.14	5.17	5.16	5.14	4.59	5.38	4.95	3.35	--	4.86	5.68	5.72
12/19/85	-0.13	4.12	4.11	4.11	3.57	2.75	-0.30	3.19	3.02	3.73	4.03	3.29	4.06	3.16	3.58	3.24	3.63	2.62	3.39	3.91	2.12	2.16
12/26/85	-0.19	3.49	3.78	3.85	3.22	2.43	0.43	2.96	2.71	3.42	3.52	2.93	3.57	2.90	3.22	2.53	3.33	2.35	3.04	3.51	-2.33	-1.73
01/02/86	-0.53	3.28	2.84	3.67	2.97	2.38	0.30	2.72	2.52	3.17	3.28	2.73	3.45	2.78	2.88	2.32	3.03	2.16	2.69	3.24	-0.07	-0.24
01/09/86 @ 11:00 AM	-0.88	--	--	3.85	3.18	2.38	-0.18	2.72	2.64	3.33	3.67	2.78	3.75	3.00	3.15	2.76	3.35	2.37	2.67	3.60	-2.56	-2.68
@ 2:00 PM	-0.85	3.77	3.83	3.88	3.22	2.31	-0.23	2.72	2.63	3.35	3.74	2.81	3.80	2.94	3.12	2.69	3.36	2.34	2.68	3.66	-3.57	-2.76
@ 4:00 PM	-0.85	3.77	3.84	3.89	3.23	2.31	-0.22	2.73	2.59	3.35	3.78	2.86	3.80	2.96	3.13	2.62	3.34	2.35	2.68	3.66	-0.81	-0.59
@ 8:00 PM	-0.78	3.78	3.84	3.88	3.21	2.40	-0.08	--	2.62	--	3.78	2.89	3.84	3.10	3.22	2.48	3.34	--	--	3.66	1.79	--
01/10/86 @ 8:00 AM	-0.70	3.73	3.82	3.87	3.18	2.41	-0.01	2.68	2.56	3.32	3.72	2.93	3.80	3.13	3.28	2.40	3.30	2.33	2.67	3.62	3.01	2.84
@ 3:00 PM	-0.74	3.68	3.85	3.87	3.17	2.26	-0.19	2.68	2.54	3.31	3.68	2.88	3.77	2.96	3.23	2.39	3.28	2.27	2.65	3.58	-4.03	-2.77
01/15/86	-0.98	3.15	3.70	3.79	2.89	2.28	-0.14	2.82	2.48	3.07	3.17	2.80	3.32	2.72	3.04	2.39	3.10	2.12	2.71	3.21	0.87	0.88

river bank. The downstream point is a staff gage installed near the drawbridge over the river on South Front street. Union County personnel at the drawbridge control building record the times and gage heights of daily high and low tides. This information was obtained for the study period. The records begin at approximately 8:00 a.m. each day and end at approximately 11:00 p.m. These records are presented in Appendix E.

The hydraulic conductivities of the shallow and deep groundwater zones were determined by performing slug tests on all NUS wells. Additional information on the shallow zone was obtained by performing a short-term pumping test on MW-002. The slug tests were performed by adding or removing a slug of a known volume of water to or from the wells and measuring the time for the water levels to return to static. The pumping test was performed by pumping MW-002 at a constant discharge rate of 1.5 gpm for 75 minutes. The pumping test and slug test data are summarized in Table 4-3.

Groundwater sampling was conducted in December 1985 and January 1986. All NUS monitoring wells except MW-007 were sampled. This well was constructed with PVC instead of stainless steel and was installed for water level information only. The groundwater quality data are presented in Appendix A and are discussed in Section 4.5.3.

Specific conductance measurements were made on all sampled NUS wells in December 1985. These data displayed some variability, therefore specific conductance measurements were made on all NUS wells and on most NJDEP wells in January 1986. These data are presented in Table 4-4. Specific conductance values ranged from 1,600 $\mu\text{mhos/cm}$ to in excess of 10,000 $\mu\text{mhos/cm}$.

4.5.2 Results of Investigation - Physical System

Two distinct groundwater zones are present. A shallow groundwater zone is present within the fill on top of the silt and clay. A deep zone is present within the glacial material on top of the bedrock, below the silt and clay. From the regional information it is also known that groundwater is present within the Brunswick Formation, however this groundwater was not investigated in this study.

The shallow zone is an unconfined water table aquifer. The depth of the water table below the ground surface varied during the study. The water levels were highest on December 12 and 13, 1985, and generally declined toward the end of the period of record. Table 4-2 shows that the water levels of some of the shallow wells were above the ground surface on December 12 and 13.

TABLE 4-3

**AQUIFER TEST SUMMARY
CHEMICAL CONTROL CORPORATION SITE**

Well	Test Performed	Analysis Method	Thickness (ft)	Hydraulic Conductivity (cm/sec)	Transmissivity (gpd/ft)	Storage Coefficient
Upper Aquifer						
MW-002	Pump Test	Pumping well drawdown and recovery	7.25	$1.7 \times 10(-3)$	255	$1.2 \times 10(-2)$ $1.0 \times 10(-2)$
		Pumping well t/t'		$1.5 \times 10(-3)$	234	
		Observation well-Theta		$2.5 \times 10(-3)$	378	
		Storage by dewatering				
	Slug test-rising head	Bouwer and Rice		$1.5 \times 10(-3)$	231	
MW-003	Slug test-rising head	Bouwer and Rice	4.51	$5.3 \times 10(-3)$	507	
	Slug test-falling head			$5.4 \times 10(-3)$		
MW-004	Slug test-composite	Bouwer and Rice	5.65	$4.3 \times 10(-2)$	5,150	
MW-005	Slug test-rising head	Bouwer and Rice	3.92	$2.7 \times 10(-4)$	22	
	Slug test-falling head			$2.9 \times 10(-4)$	24	
	Slug test-rising head		3.72	$2.9 \times 10(-4)$	23	
	Slug test-falling head			$2.5 \times 10(-4)$	20	
MW-006	Slug test-rising head	Bouwer and Rice	4.62	$1.1 \times 10(-3)$	108	
	Slug test-falling head			$1.2 \times 10(-3)$	111	
	Slug test-rising head		4.75	$1.6 \times 10(-3)$	161	
	Slug test-falling head			$7.5 \times 10(-4)$	76	
MW-008	Slug test-falling head	Bouwer and Rice	2.65	$5.0 \times 10(-4)$	28	
MW-009	Slug test-rising head	Bouwer and Rice	7.01	$9.8 \times 10(-3)$	1,450	
MW-010	Slug test-rising head	Bouwer and Rice	6.05	$2.7 \times 10(-4)$	35	
	Slug test-falling head			$2.4 \times 10(-4)$	31	
Lower Aquifer						
MW-001	Slug test-rising head	Papadopoulos	11	$3.3 \times 10(-5)$	7.7	$1 \times 10(-2)$
				$3.8 \times 10(-5)$	8.9	$1 \times 10(-1)$
MW-007	Slug test-rising head	Papadopoulos	12.5	$2.3 \times 10(-3)$	610	$1 \times 10(-5)$
	Slug test-falling head			$1.6 \times 10(-3)$	424	$1 \times 10(-3)$
	Slug test-rising head			$2.3 \times 10(-3)$	610	$1 \times 10(-4)$
	Slug test-rising head			$1.3 \times 10(-3)$	345	$1 \times 10(-2)$

TABLE 4-4
SPECIFIC CONDUCTANCE DATA
CHEMICAL CONTROL CORPORATION

<u>Well</u>	<u>Specific Conductance (μmhos/cm)</u>	
	<u>12/11/1985</u>	<u>01/16/1986</u>
NUS Wells		
MW-001	+10,000	+10,000
MW-002	+10,000	+10,000
MW-003	+10,000	+10,000
MW-004	4,900	+10,000
MW-005	3,500	7,200
MW-006	6,100	6,800
MW-007	--	+10,000
MW-008	2,300	3,200
MW-009	2,100	8,200
MW-010	1,600	1,800
NJDEP Wells		
1	--	--
2	--	+10,000
3	--	--
4	--	6,900
5	--	+10,000
6	--	+10,000
7	--	7,000
8	--	5,200
7-2	--	--
TW-15	--	+10,000

The deep groundwater zone is confined or semi-confined. The water level of MW-001 is 13 to 15 feet above the top of the glacial material while the water level of MW-007 is 22 to 23 feet above the top of the glacial material. The overlying confining bed is the silt and clay tidal marsh deposit.

There is a downward hydraulic gradient between the shallow and deep groundwater zones. This is illustrated in Figure 4-10 and in Table 4-2. The difference between the water levels of the two zones ranges from three to five feet, and averages approximately 4 feet.

The hydraulic conductivity of the shallow zone varies from 10^{-2} to 10^{-4} cm/sec. Multiplying the hydraulic conductivity by the saturated thickness yields the transmissivity, which ranges from approximately 20 to 5,150 gpd/ft. The specific yield of the shallow zone determined from the pumping test is 0.01, which is indicative of unconfined conditions. The effective porosity is estimated to be 20 percent.

The hydraulic conductivity of the deep groundwater zone is 10^{-5} cm/sec at MW-001 and 10^{-3} cm/sec at MW-007. These values, when multiplied by the total thickness of the glacial materials at both wells, yield transmissivities ranging from 8 to 610 gpd/ft.

The water levels in the shallow zone declined after December 12 and 13, when NUS personnel reported that the Elizabeth River flooded the site. The water level decline was fairly consistent until approximately December 22. After this the water level of MW-003 continued to decline until the beginning of January 1986, when it rose sharply, while the water level of MW-002 alternately rose and fell until the beginning of January, when it also rose sharply.

The early water level decline is interpreted to result from groundwater discharge. The source of this groundwater is the "slug" of water from the overbank flood.

December 12 and 13 correspond to the predicted maximum monthly high tide. The next predicted maximum monthly high tide occurred on January 9 and 10. Water levels in the wells and on the river were measured six times over these two days to assess the effects of this high tide on the groundwater regime.

The January high tide event did not produce overbank flooding even though the predicted height of this tide was equal to the predicted height of the December event. Other factors must combine to produce a rise in the river stage so that it is sufficient to inundate the site. One of these factors must be the flow in the river itself. Table 5-1, which presents the flow of the Elizabeth River recorded at a USGS gaging station 3.8 miles upstream from the site, shows that the river flow was greater on December 12 and 13 than on January 9 and 10. County

personnel at the drawbridge report that high winds coming off the Arthur Kill can back up the river and can also cause abnormally high river stages.

The information suggests that the Chemical Control Site probably floods with some regularity, however the frequency of the flooding and the time of an individual inundation is difficult to predict. The stage of the river is a function of the tide, the flow in the river itself, and reportedly winds. These factors must interact in some combination to produce sufficient river stages to flood the site.

The January 9 and 10 water level survey also established that individual high tides which do not flood the site have little effect on the water levels of the wells in the shallow zone. Table 4-2 shows that these water levels change only slightly from a non-overbank high tide, even though the river stage elevation is above the water levels of some of the shallow wells.

This observation is attributed to the effects of bank storage. As an individual high tide event occurs, this will cause a short-term hydraulic gradient from the river into the site. As the high tide leaves, the gradient will be reversed and groundwater from the river bank will flow back into the river. The influences of the tidal fluctuations are therefore most pronounced at the river bank, and dissipate a short distance away from the river. The overbank high tides have a dramatic influence on the shallow groundwater regime, while the non-overbank tides have only a minimal influence.

The water levels of MW-002 and MW-003 rise sharply at the beginning of January 1986. The precipitation data presented in Table 2-2 showed that 0.35 and 0.40 inches of rain were recorded at the Newark Airport on January 3 and 5, respectively. The water level increases in the wells are much greater than the amount of the rainfall. This can occur in an unconfined aquifer as a result of air entrapment between the water table and the downward percolating rainfall.

The water level of MW-001 presented in Figure 4-10 shows a general decline similar to that in shallow wells MW-002 and MW-003. However, superimposed on this trend are a series of smaller short-term peaks and valleys which represent small, short-term water level fluctuations. Both the general decline and the short-term fluctuations are attributed to changes in the total stress acting on the deep groundwater zone.

The times of the short-term peaks and valleys on the water level record correlate to the times of the daily high and low tides, respectively. There is an approximate 2.5 hour time lag between the time of a high or low tide and the time of the next peak or valley on the water level record. This regularity suggests that the well's short-term fluctuations are tidally influenced.

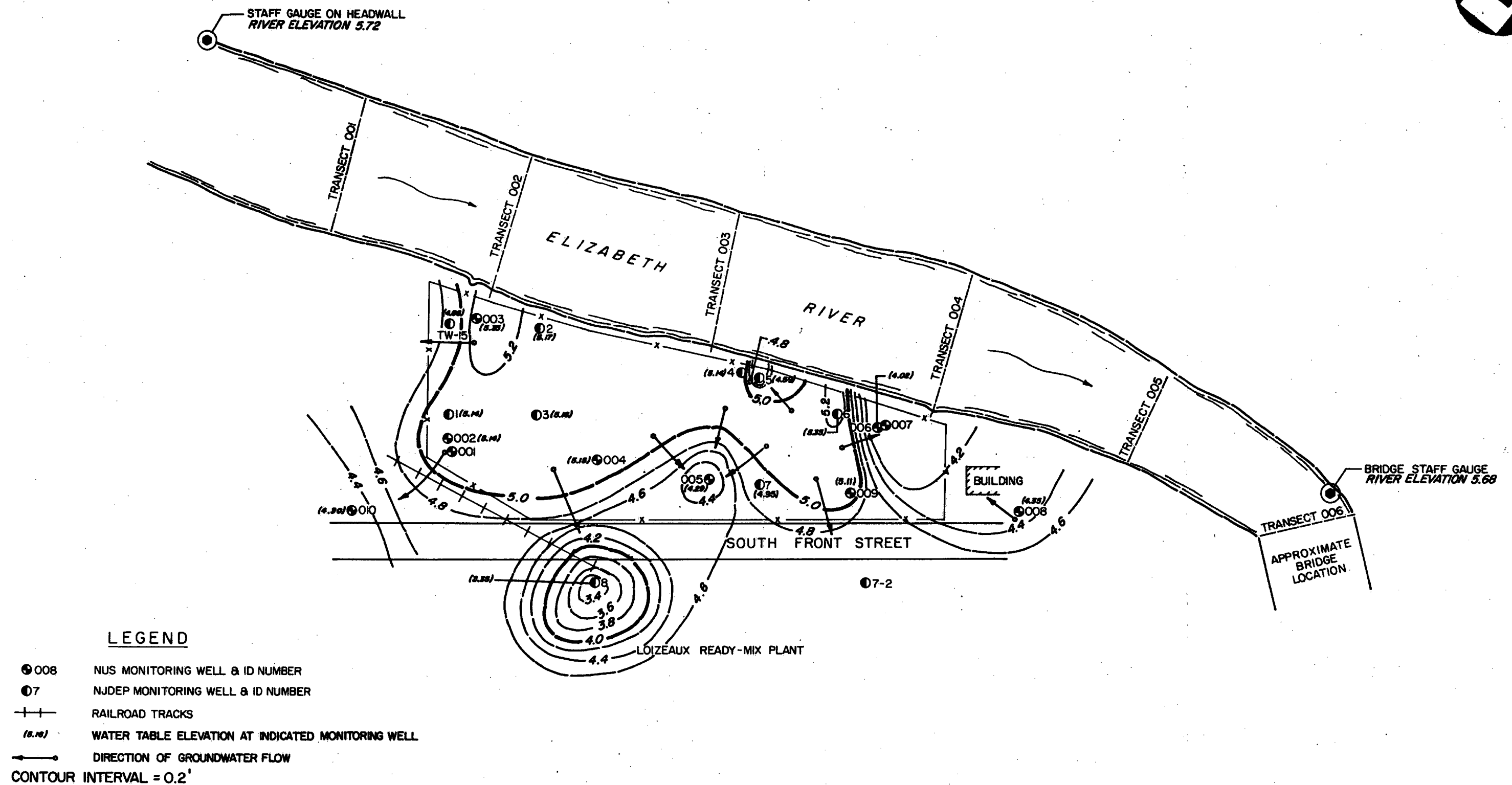
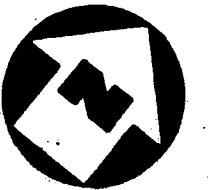
This may be explained by changes in the total stress acting on the deep zone. As the tide changes, the height of water in the Elizabeth River changes, hence the weight of water overlying the portion of the deep zone below the river changes. The change in weight would produce a change in the total stress acting on the deep zone near and below the river. High tides would cause increased total stresses, which would produce water level rises in the deep zone. Low tides would cause decreased total stresses, which would produce water level decreases in the deep zone.

The general decline in the water level of MW-001 may also result from changes in the total stress acting on the deeper zone. The water level in the shallow groundwater zone decreased during the study as mentioned previously. Since the shallow zone is unconfined, this water level decline indicates that the shallow zone actually lost water. This would reduce the weight of water overlying the deep zone, reducing the total stress acting on the deep zone, and lowering the water level of MW-001. The general decline is much larger than the smaller short-term fluctuations attributed to the tides. The area of the deep zone covered by the shallow zone is much larger than the area covered by the river, which would produce a larger change in the total stress, causing a larger change in the water level of MW-001.

The direction of the groundwater flow in the shallow zone was estimated by plotting contours of the water table surface based on data from the shallow wells. Water table contours from two different days derived by considering two different hydrogeologic conditions are presented in Figures 4-11 through 4-14.

The consideration of different hydrogeologic conditions was undertaken because of reported information from the NJDEP that South Front Street may act as a hydraulic barrier, prohibiting groundwater flow across it. The groundwater data collected neither proved nor disproved this point. Therefore the shallow groundwater system was evaluated by considering that the road may or may not be an impermeable barrier. Figures 4-11 and 4-13 present the estimated flow pattern in the shallow zone if the road is not an impermeable boundary, while Figures 4-12 and 4-14 present the estimated flow pattern if the road does act as an impermeable barrier.

NJDEP well No. 8 consistently has a lower water level than any of the shallow wells north of the road. If it is assumed that the road is not an impermeable boundary, the resulting pattern suggests that there is a groundwater sink in the vicinity of NJDEP No. 8, and that groundwater from the Chemical Control Site migrates across the street towards it. If the road is an impermeable boundary, then the water levels of the wells south of the road have no relationship to the water levels of the wells north of the road.



WATER TABLE CONTOURS -12/12/85 (INCLUDING WELLS SOUTH OF SOUTH FRONT STREET)
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ

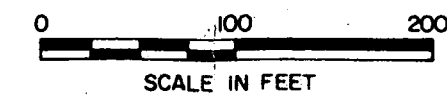
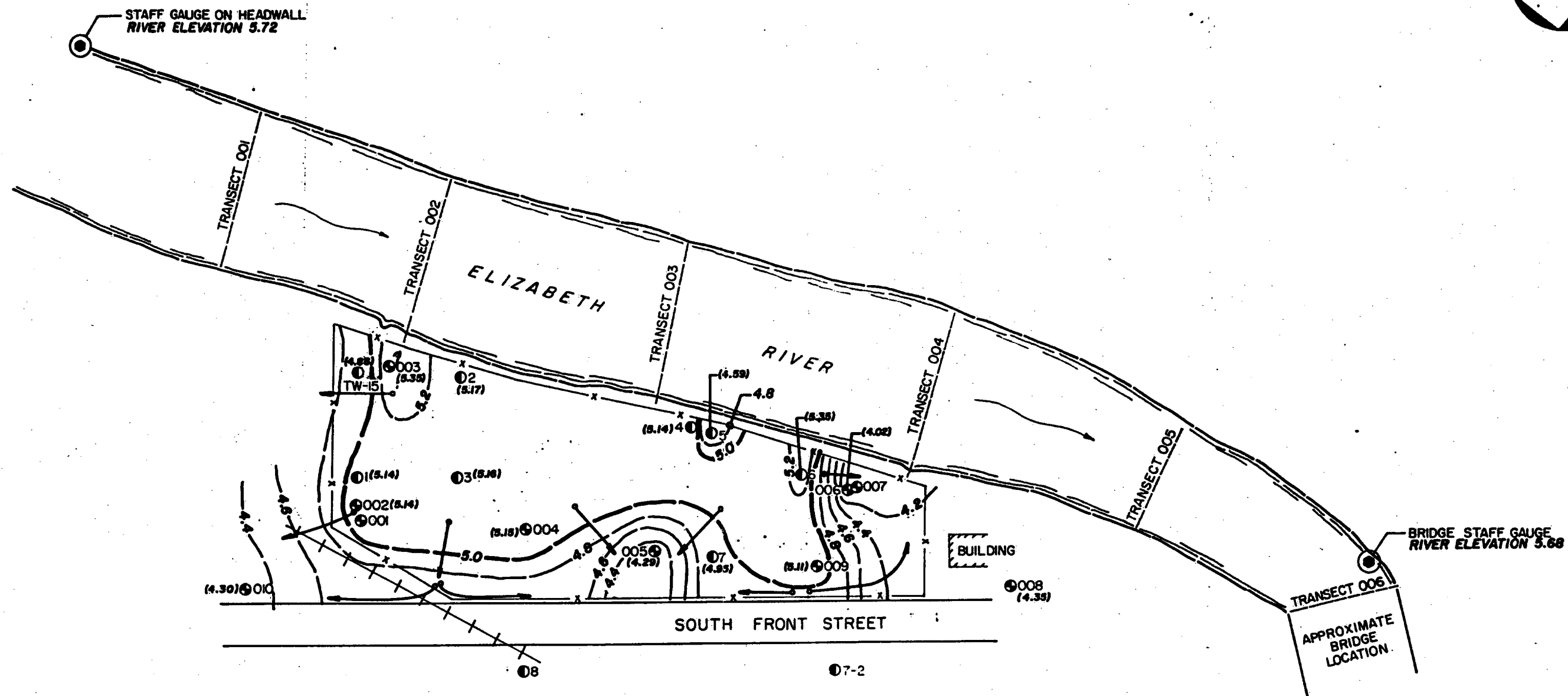
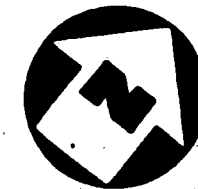
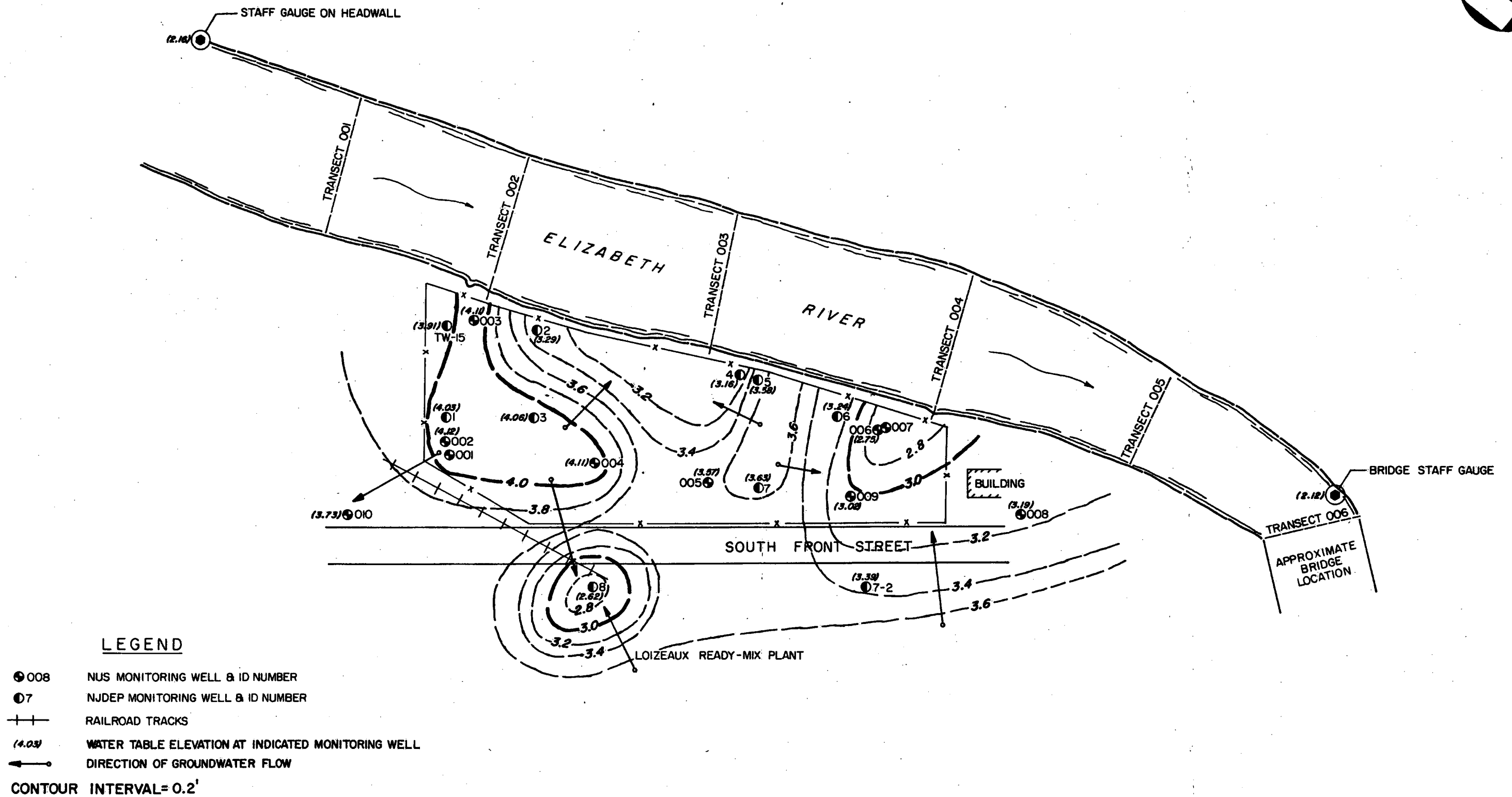
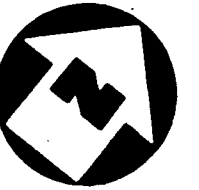


FIGURE 4-11







**WATER TABLE CONTOURS-12/19/85 (INCLUDING WELLS SOUTH OF SOUTH FRONT STREET)
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ**

FIGURE 4-13

The groundwater sink in the vicinity of MW-8 may be a result of groundwater infiltration into the storm sewer system. A storm sewer line runs along South Front Street on the same side of the road as MW-8. If this sewer line or the catch basins connected to it leak, this would allow the infiltration of groundwater into the storm sewer system. The situation would be analogous to that of a pumping well withdrawing groundwater. This could in effect produce a cone of depression in the shallow groundwater system, depicted in Figures 4-11 and 4-13.

The U.S. Army Corps of Engineers, New York Construction District, managed the sewer restoration project mentioned in Section 1.1.4. Their personnel report that the storm sewer system is connected to the Arthur Kill at the sewer outfall. As the tide rises and falls within the Kill, water levels within the catch basins rise and fall.

To clean and inspect the sewer system, they attempted to block off the sewer line and pump the system dry. They discovered that an unspecified amount of groundwater infiltrated into the storm sewer system when doing this.

It is therefore probable that the relatively low water level of MW-8 is a result of groundwater infiltration into the storm sewer system. This infiltration would occur when the water level in the shallow groundwater system is higher than the water level or head in the sewer system where the leaks are located.

The infiltration of groundwater into the storm sewers would affect the shallow groundwater flow patterns on the Chemical Control Site only if South Front Street is not an impermeable boundary. If this road is an impermeable boundary, then the groundwater from Chemical Control could not cross the road and infiltrate the sewer system. The groundwater flow pattern on site in this case would be as shown in Figures 4-12 and 4-14. These show that groundwater flow on the west end of the site would not cross the road but would be deflected by it and migrate towards discharge points along the Elizabeth River.

The shallow groundwater flow patterns shown for December 12 indicate that there is essentially a groundwater front moving across the site from the river to the road. This was a day the site flooded as mentioned previously.

The groundwater flow patterns shown for December 19 are the more typical for the site under non-flood conditions. There is a groundwater high on the west end of the site. Discharge points appear along the river near MW-006 and between NJDEP wells No. 4 and No. 2. These patterns represent the groundwater flow conditions after the flood.

The groundwater flow patterns on both days, under both possible scenarios, show considerable bending and are not uniform. This

is interpreted to result from the large range of hydraulic conductivities that were determined in the slug tests. Because of this range it is difficult to characterize an average or representative hydraulic conductivity for the shallow zone. This is not unexpected because the shallow zone is comprised of man-made fill and is not a natural deposit.

The quantity of groundwater discharge offsite from the shallow zone was estimated in two ways. The first estimated the discharge based on the reduction in the water levels in the shallow zone during different time periods following the December flood. The second estimated the discharge by dividing the site into different parts and applying an average hydraulic gradient, hydraulic conductivity, and area to each part. The sum of the discharges determined for each part was considered the total groundwater discharge from the shallow zone. The calculations are presented in Appendix B.

The results show that after the flood, the maximum daily groundwater discharge from the shallow zone was approximately 49,000 gpd. In the first week following the flood, the discharge averaged approximately 16,000 gpd. Under more normal, non-flood circumstances, the groundwater flow was estimated to be approximately 640 gpd.

The discharges estimated by considering the water level drop in the shallow zone are higher than can be calculated with the hydraulic conductivity and hydraulic gradient values determined in the study. Some of the groundwater may have left the site in the form of surface runoff. Some may have discharged from the site as large seeps from the upper coarse gravel fill in areas where breaks have been cut in the clay dike along the river bank. NUS personnel observed seepage from this area following the flood events.

The amount of vertical seepage through the silt and clay separating the upper and lower groundwater zones is not known. However it is likely that there is some seepage. If the hydraulic conductivity of the silt and clay is estimated to be 10^{-6} cm/sec, the approximate 4-foot head difference between the upper and lower aquifers would produce approximately 460 gpd of downward seepage.

The direction and magnitude of groundwater flow in the deep zone cannot be determined because there are only two data points in this zone. However, the low hydraulic conductivity of the glacial material, and the position of the deep zone underneath the silt and clay, suggest that downward seepage into this zone and movement within this zone are less important than the discharge from the shallow zone into the Elizabeth River.

4.5.3 Results of Investigation - Extent of Contamination

Groundwater samples were collected from nine NUS-installed monitoring wells on two separate occasions. Field measurements of specific conductance and pH were made at the time of sampling. Samples were submitted to CLP labs for full HSL analysis. Groundwater and surface water samples were analyzed for special analytes including: chloride; sulfate; nitrate; carbonate; bicarbonate; acidity; alkalinity; total dissolved solids; and total suspended solids. The complete analytical data and field results for these samples are included in Appendix A.

Review of the Special Analytical Services (SAS) and inorganic data for groundwater and surface water samples (Appendix A) indicates that site groundwater and the Elizabeth River are brackish in nature. For example, inorganic substances such as calcium, magnesium, and sodium were detected at average concentrations of 160 mg/l, 190 mg/l, and 2,000 mg/l, respectively, in 20 groundwater samples. Concentrations of these analytes in 9 surface water samples from the Elizabeth River averaged 150 mg/l, 440 mg/l, and 3,400 mg/l, respectively. Typical seawater concentrations of these inorganics are 400 mg/l, 1,350 mg/l, and 10,500 mg/l, respectively (Bowen, 1966 and Driscoll, 1986).

Further evidence of the high dissolved solids content of site groundwater is provided by the specific conductance values presented in Table 4-4, and by the Total Dissolved Solids (TDS) values presented in Appendix A. TDS concentrations ranged from 752 mg/l to 15,700 mg/l in samples from the shallow groundwater zone (average concentration = 5,000 mg/l). A TDS concentration of 23,200 mg/l was reported for the sample collected from the deep monitoring well (MW-001). The reported shallow aquifer TDS values generally fall in the range of brackish water (1,000 to 10,000 mg/l), while that for the confined/semi-confined aquifer falls in the range of saline water (10,000 to 100,000 mg/l) (Driscoll, 1986). For comparative purposes, TDS values for groundwater occupying quarternary deposits (overburden) in Union County, New Jersey ranged from 200 to 353 mg/l in 5 samples collected by the Rahway Water Department (Nemickas, B., 1976).

These results indicate that mixing of freshwater and sea water occurs in the vicinity of the Chemical Control Corporation Site. The high solids content of the groundwater indicates that at least one of several different conditions may exist: 1) saltwater intrusion has occurred as a result of aquifer development; 2) aquifer recharge at high tide introduces saltwater to the shall aquifer; 3) the site is in the vicinity of the naturally occurring fresh/sea water interface.

The Brunswick (Bedrock) formation is the primary source of potable and industrial groundwater in Union County. The closest public wellfield is in Roselle, approximately 3 miles inland

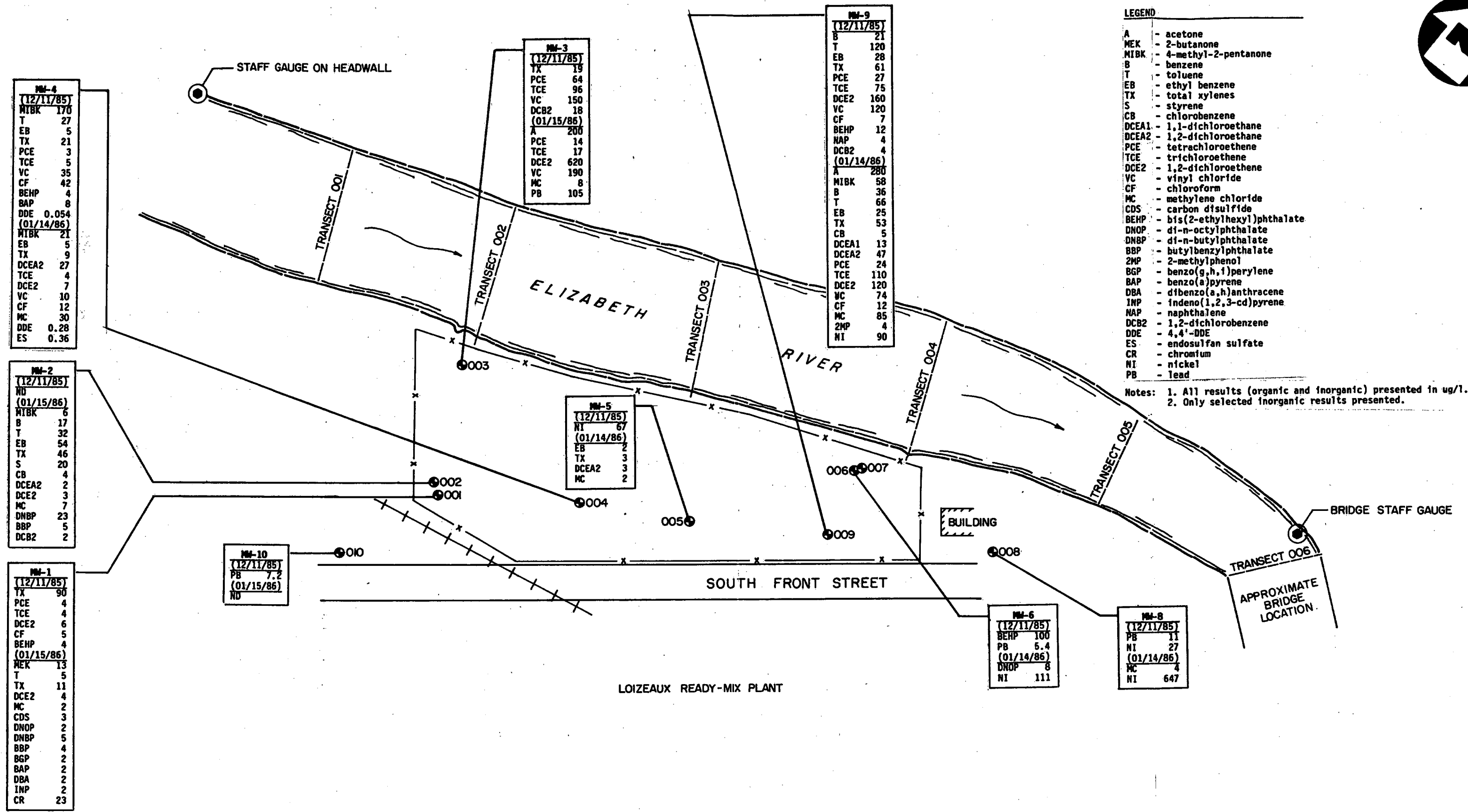
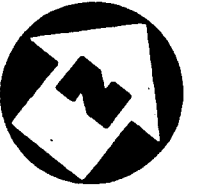
from the Chemical Control Corporation Site location (Nemickas, B., 1976). Groundwater occurs only sporadically in the quaternary deposits in Union County. Thus, it is considered unlikely that saltwater intrusion as a result of aquifer development accounts for the high dissolved solids content of site groundwater.

It is believed that aquifer recharge from adjacent surface water bodies accounts for the high TDS content of the groundwater in the shallow aquifer. Although the hydrologic investigation indicates that normal high tides do not have a pronounced effect on water levels in the shallow aquifer, the effect of overbank high tides on the water levels has been demonstrated. Such occurrences (site flooding), coupled with short term reversals of the hydraulic gradient because of normal tidal influence are considered the best explanation for the high TDS content of shallow aquifer groundwater. Comparison of the calcium, magnesium, and sodium values for groundwater and Elizabeth River samples provides a clear indication of this possibility. The high TDS content of the confined/semi-confined aquifer is probably a result of proximity to the static fresh water/sea water interface. There tends to be a mixing of salt water and fresh water in a zone of diffusion around such an interface (Freeze and Cherry, 1979). Thus, a well need not be screened directly to the salt water zone to exhibit high TDS content.

Groundwater samples contained a number of HSL organic chemicals. Volatile organics were identified most frequently and at the highest concentrations. Acid and base/neutral extractables and pesticide compounds were also detected, although sporadically and at relatively low concentrations.

Figure 4-15 summarizes the occurrence and distribution of organic and inorganic chemicals in groundwater samples. This figure presents compound specific results for each sample. The predominant groundwater contaminants are volatile organic compounds, including the following general classes of chemicals: ketones; monocyclic aromatics; and halogenated aliphatic hydrocarbons. Phthalate esters, PAHs, phenols, and chlorinated benzenes were also detected; generally on the order of instrument detection limits (approximately 5-10 mg/L).

Figure 4-15 reveals that samples from monitoring wells MW-001, 002, 003, 004, and 009 contain the highest concentrations of organic chemicals detected in groundwater at the site. Total volatile organic concentrations (TVO) in these samples ranged to approximately 1 mg/L (ppm). Samples obtained during installation of these wells indicated the presence of the volatile organics and other chemicals in the subsurface media. The results for these wells confirm the belief that residual contamination (contaminant source areas) exists in the vicinity of these wells (see Section 4.4.3).



ANALYTICAL RESULTS-GROUNDWATER SAMPLES
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ



The results for samples obtained from the well screened below the silt and clay layer (MW-001) indicate that chemicals have permeated this layer. With the exception of xylenes, organic chemicals were not detected above 15 mg/L in these samples. The data indicate that no appreciable contaminant migration through the clay/silt layer has occurred.

With the exception of vinyl chloride, all of the groundwater contaminants were detected in near-surface or subsurface soils. The presence of vinyl chloride is probably attributable to the reductive dehalogenation of trichloroethane (Cline and Viste, 1984).

All results for the inorganic chemicals of interest (arsenic, cadmium, chromium, lead, mercury, and nickel) are also included (see Section 4.3.3). These chemicals were infrequently detected in groundwater samples. The only well displaying consistent results with respect to the inorganics was monitoring well MW-008. The samples from this well contained nickel on both sampling occasions (27 mg/L and 647 mg/L for the respective sampling episodes).

In conclusion, groundwater is contaminated with inorganic and organic chemicals. Only the volatile organics appear consistently and at relatively high concentrations. Groundwater results correspond well with the results of the subsurface soil investigation; the most highly contaminated samples were collected from areas of extensive subsurface soil impact.

4.6 SUMMARY OF HYDROGEOLOGIC INVESTIGATION

4.6.1 Summary of Physical Hydrogeologic System

Two groundwater zones are present on site. A shallow, unconfined groundwater zone is present within the fill on top of an 11 to 19-foot-thick silt and clay. A deep groundwater zone is present within glacial till underneath the silt and clay. There is a downward hydraulic gradient averaging approximately 4 feet between the two zones.

The tidal fluctuations of the Elizabeth River have a pronounced effect on the shallow groundwater zone only when the tide and other factors, such as the river flow and winds, combine to cause the river to flood the site. Groundwater discharges out of the shallow zone following this type of inundation. High tides which do not cause the river to flood have a minimal effect on the groundwater flow in the shallow zone, probably as a result of bank storage. The frequency of site inundation and the times of individual flood events are difficult to determine because several factors influence the river stage.

It is estimated that groundwater primarily discharges off site into the Elizabeth River, however it is possible that groundwater seeps into the storm sewer system. Regardless of its

pathway, the groundwater reaches the Arthur Kill. There is evidence of vertical seepage through the silt and clay underlying the shallow groundwater zone, however this is not considered as significant a part of the groundwater system as is the discharge from the shallow zone into the Elizabeth River.

4.6.2 Summary of Extent of Contamination

The following items summarize the results of the chemical-analytical hydrogeologic investigation:

- Figures 4-4, 4-5, 4-9, and 4-15 display the spacial extent of contamination in near-surface material, subsurface material, and groundwater.
- The new gravel fill is considered essentially clean, except at the interface with the underlying material.
- The shallow old fill contains high concentrations of PAHs, phthalate esters, PCBs, and some inorganic chemicals.
- These chemicals are also present deeper in the old fill, as shown by the analytical results for split spoon samples. High concentrations of volatile organic chemicals were also detected in old fill samples obtained at depth.
- Volatile organic chemicals were detected in a number of the groundwater samples. Other acid and base/neutral extractable and pesticide fraction (4,4'-DDE and endosulfan sulfate) compounds were detected in the groundwater samples, although only sporadically and at relatively low concentrations (on the order of instrument detection limits).
- Two areas of the site (the southwestern portion and the area in the immediate vicinity of MW-009) display greater concentrations of chemicals in both groundwater and subsurface material. Residual contamination appears greatest in these areas.
- Some residual contamination exists in the shallow subsurface material in the former drum staging area. The data do not indicate an areally extensive contamination problem. Concentrations of chemical contaminants are lower in this area than on the site proper.

4.6.3 Contaminant Release and Migration

Contaminant release mechanisms and environmental transport pathways can be inferred from the available hydrogeologic and analytical data. The material presented in the preceding

portions of this section directly supports the discussion that follows.

Neither surface water nor wind erosion constitute contaminant release mechanisms. The nature of the surface material (coarse gravel fill) preclude contaminant release via either of these means. In addition, it is considered unlikely that the gravel will be eroded under present site conditions. Analytical results for gravel samples provide an indication that HSL contaminants are not present in the surface gravel itself. These data have been invalidated, but it is believed that the negative findings are consistent with site history and valid results for the top of the old fill material. The composited new gravel fill samples do indicate that the gravel is sporadically contaminated with organic chemicals (most notably PCBs). These chemicals are presumed to be present only at the base of the gravel as a result of direct contact with contaminants in the underlying old fill. PCBs were present at high concentrations in the old fill directly below the gravel at several of these locations. Volatilization is virtually the only mechanism which could introduce chemicals to gravel on the surface of the site, but PCBs have very low volatilities (see Section 3.0).

Although volatile organic chemicals are present at the site, they are primarily confined to the deeper subsurface material. Volatile organic chemicals were virtually undetected in the near-surface samples obtained directly below the gravel fill. Thus any substantial release of volatile organic chemicals to the ambient air is not anticipated. Although volatilization may occur to a slight degree, reports by field operations personnel indicate that rapid dispersion will occur if release via this mechanism takes place. During installation of monitoring wells, volatile emissions were observed because of disturbance of the subsurface media. However, after backing off from the wells, it was noted that concentrations rapidly diminished, and drilling resumed. Even during such disturbances, substantial contaminant release via volatilization was not observed.

Under present site conditions contaminant release is expected to occur only through leachate generation and subsequent groundwater advection of leachable contaminants. Leachable contaminants consist primarily of volatile organic chemicals. The results for groundwater samples conform to the anticipated environmental behavior of the various chemicals detected at the site. Only the water-soluble phenols and volatile organics were detected in groundwater at concentrations that exceeded instrument detection limits. Only very low levels of the slightly water soluble phthalate esters were detected in groundwater samples. These substances generally have very high soil/sediment adsorption coefficients and thus display an affinity for soil organic matter.

Contrast of subsurface soil and groundwater results indicates that the volatile organic chemicals are not being leached from the soil matrix at concentrations that would normally be anticipated. Several factors are considered responsible for this apparent anomaly. The first of these is the saline nature of the groundwater beneath the site. The presence of dissolved salts in groundwater or surface water is known to decrease the solubility of various organic chemicals (Lyman, et. al., 1984, and Masterton, et. al., 1972). The second of these is the presence of the silt and clay deposits beneath the site. The organic nature of these deposits will attenuate organic chemicals via adsorption once they come in contact with these materials. Both of these factors probably contribute to the favorable partitioning of chemicals in the solid phase over the groundwater. Although a vertical (downward) groundwater gradient exists across the silt and clay layer, the analytical results for the deep well (MW-001) do not indicate that substantial migration of chemicals through this layer has occurred.

Chemicals contained in the fill deposits overlying the clay and silt layer will be more readily released from the site. The available data indicate that the predominant contaminants remaining in this zone are the water-insoluble species. However, groundwater results for the shallow monitoring wells indicate that some volatile organic chemicals are being leached from the fill and are impacting the groundwater.

In view of the hydrogeology of the site (as discussed above), the ultimate fate of these contaminants is probably discharge to the Elizabeth River. In order to assess potential impact on the Elizabeth River under present site conditions, a simple mass balance was used to predict river water concentrations under two different scenarios: normal groundwater base flow conditions; and maximum discharge conditions (i.e., those observed following the flood in December 1985). The maximum concentrations of the chemicals detected in site groundwater were used in the analysis and were assumed to extend over the entire area of the site. The 10-year, 7-day low flow (Q7-10) reported by the U.S. Geological Survey for the Elizabeth River at Elizabeth (1.9 cfs) was employed in the mass balance. Additional assumptions and calculations are included in Appendix B. The results of this analysis are presented in the following table.

Groundwater Contaminant	Maximum Observed Concentration (µg/L)	Downstream Concentration (µg/L)	
		Base Flow	Maximum Discharge
acetone	280	1.6×10^{-1}	11
2-butanone	13	7.3×10^{-3}	0.51
4-methyl-2-pentanone	170	9.4×10^{-2}	6.6
benzene	36	2.0×10^{-2}	1.4
toluene	120	6.7×10^{-2}	4.7
ethylbenzene	54	3.0×10^{-2}	2.1
total xylenes	90	5.0×10^{-2}	3.5
styrene	20	1.1×10^{-2}	0.8
chlorobenzene	5	2.8×10^{-3}	0.2
1,1-dichloroethane	13	7.3×10^{-3}	0.5
1,2-dichloroethane	47	2.6×10^{-2}	1.8
tetrachloroethene	64	3.6×10^{-2}	2.5
trichloroethene	110	6.1×10^{-2}	4.3
1,2-dichloroethene	620	3.5×10^{-1}	24
vinyl chloride	190	1.1×10^{-1}	7.4
chloroform	42	2.3×10^{-2}	16
bis(2-ethylhexyl) phthalate	100	5.6×10^{-2}	3.9
di-n-butyl phthalate	23	1.3×10^{-2}	0.9
1,2-dichlorobenzene	18	1.0×10^{-2}	0.7

The table indicates that even using this conservative analysis, contaminants will reach the river only at barely measurable levels, and only under extreme worst- case (maximum discharge) conditions. Among the factors which make this analysis overly conservative are the following:

- The average flow rate of the Elizabeth River is 10,800 gpm (U. S. Army Corps of Engineers, June 1985), which greatly exceeds the value of 1,350 gpm used in the mass balance.
- The rapid discharge of groundwater following inundation of the site will preclude equilibration of chemical concentrations between the soil and groundwater (chemicals will remain bound in soil).
- If conditions are such that if the site floods, the flow rate of the river will probably exceed the average daily flow rate.
- It was assumed that contaminant concentrations are continuous throughout the site. This is not the case in reality.
- The analysis does not account for attenuation of chemicals by the sediment column.
- The analysis does not account for volatilization from the river.

5.0 SURFACE WATER AND SEDIMENT INVESTIGATION

5.1 OBJECTIVES OF INVESTIGATION

5.1.1 Surface Water

The water quality of the Elizabeth River was investigated to determine the existence of contamination and to evaluate any potential health threats that could result from the use of the river. Also, the stage of the river was investigated in conjunction with the groundwater study to determine the effects of river stage fluctuations on the groundwater regime.

5.1.2 Sediments

The sediments underlying the Elizabeth River were investigated to determine the existence of contamination both at the surface and at depth, and to evaluate any health or environmental threats from contamination in the river substrate.

5.2 SURFACE WATER INVESTIGATION

5.2.1 Methods of Investigation

Surface water samples were collected in December 1985 at four transects across the Elizabeth River, transects 001, 002, 004, and 005, shown in Figures 4-3 and 4-6. Separate samples were obtained from two points on each transect, one in the middle of the river and one approximately 5 feet from the southern shore. Grab samples were obtained, with sampling progressing upstream from transect 005 to transect 001. The samples were obtained at low tides.

Samples were also obtained from two seeps draining from the site. These sampling locations are presented in Figure 4-6. These samples were also obtained at low tide. Grab samples were obtained at each location after digging small holes to facilitate sample collection.

Upon review of the first and of surface water (and sediment) samples, it became apparent that alternate sources of environmental contamination may exist upstream of the Chemical Control Corporation Site. Additional surface water samples were collected from the Elizabeth River in May 1986 to determine the condition of the river upstream. Water samples were also collected from 5 manholes in the storm sewer system, to determine if the storm sewer system is a migration pathway from the site to the Arthur Kill.

Twenty-three surface water samples were collected from the Elizabeth River at midstream locations at distances ranging to 2-miles upstream of the site (samples were collected every 400-feet). Surface water sampling locations are provided on

Drawing S769-49-01 (in the back pocket of this report). Manhole sampling locations are provided in Figure A-1 (Appendix A).

The stage of the river was investigated by measuring the river elevation at two points shown in Figures 4-3 and 4-6. Measurements were made concurrently with water level measurements of the monitoring wells. The downstream station is located at the drawbridge which is staffed by Union County personnel, as mentioned previously. Records of the high and low tides maintained by the county at this site were obtained for the study. These data are presented in Appendix E.

The flow of the Elizabeth River during the study period was obtained from the USGS Water Resources Division. Gaging station #393450 is located on the Elizabeth River, approximately 3.8 miles upstream from the site. Only provisional, unchecked, data is available for the study period at this time. The USGS also supplied low flow information on this gaging station for the water years 1982-1985. The streamflow data is presented in Tables 5-1 and 5-2.

5.2.2 Results of Investigation - Physical System

The stage of the Elizabeth River adjacent to the site is a function of the magnitude of the tide, the flow in the river, and probably winds. This is illustrated by the fact that the December monthly high tide, which occurred on December 12 and 13, 1985, caused the river to rise sufficiently to inundate the site, while the January high tide, which occurred on January 9 and 10, 1986, did not. This is despite the fact that the predicted tide heights of each of these two events was the same. The streamflow data indicates that the flow of the river was greater on December 12 and 13 than on January 9 and 10.

The streamflow data in Table 5-1 shows that other days had considerably higher discharges than the discharges recorded on December 12 and 13, yet the river did not flood the site on these days. This is interpreted to indicate that the tide is the dominant factor in controlling the stage of the river. Measurements in Table 4-2 show that the tide can produce up to a 10-foot change in the water level of the river.

The specific measurements of stream stage show that the river gradient is often reversed, with surface water flowing "upstream," or away from the Arthur Kill on occasion. This occurs as the tide flows in from the Kill.

Table 5-2 presents the minimum daily mean flow rates of the Elizabeth River for the water years 1982 to 1985 (a water year encompasses the period from October 1 to September 30. It is the time period used by the USGS to report stream flow data). The lowest daily mean flow rate recorded was 3.0 cfs in 1983. The average of the minimum daily mean flow rates for this period (1982-1985) is 3.85 cfs. The minimum flow is expected to

TABLE 5-1

**ELIZABETH RIVER DISCHARGE RECORDS
CHEMICAL CONTROL CORPORATION**

Date	Daily Menu Discharge (cfs)	Date	Daily Menu Discharge (cfs)
December 1985		24	9.0
1	40	25	8.5
2	50	26	8.5
3	16	27	8.6
4	13	28	8.3
5	12	29	8.2
6	28	30	8.5
7	15	31	8.2
8	12	January 1986	
9	12	1	7.9
10	11	2	8.2
11	16	3	39
12	19	4	9.8
13	18	5	68
14	14	6	11
15	9.5	7	9.4
16	9.7	8	12
17	9.9	9	9.2
18	9.7	10	9.0
19	9.4	11	8.4
20	9.3	12	8.0
21	9.0	13	8.4
22	9.3	14	8.7
23	9.3	15	8.5
	9.3	16	8.3

Data from USGS Water Resources Division, Trenton, New Jersey. Gaging station #393450 on Elizabeth River, 3.8 miles upstream from site.

TABLE 5-2

ELIZABETH RIVER FLOW RECORDS
CHEMICAL CONTROL CORPORATION

Water Year	Minimum Daily Mean Flow (cfs)
1982	3.4
1983	3.0
1984	4.5
1985	4.5
Average	3.85

Data from USGS Water Resources Division, Trenton, New Jersey. Gaging station #393450 on Elizabeth River, 3.8 miles upstream from site.

increase downstream in a basin, therefore the minimum daily flow of the river at the Chemical Control site should be greater than the figures provided.

5.2.3 Results of Investigation - Extent of Contamination

As previously discussed, surface water samples were collected at low tide from two leachate seeps, from two locations (near the south shore and the middle) at each of four transects on the Elizabeth River (1, 2, 4, and 5), at 23 locations on the Elizabeth River upstream, adjacent to, and downstream of the site, and from 5 manholes in the storm sewer system. Samples were submitted for full HSL analysis. Complete analytical results for surface water samples are presented in Appendix A.

Leachate Seep Samples

Volatile organic, base-neutral extractable and inorganic chemicals were detected in the leachate seep sample from seep number 1 (see Figure 4-6). Chemicals detected in this sample include the following: trichloroethene (300 mg/L); 1,2-dichloroethene (2,100 mg/L); vinyl chloride (600 mg/L); bis(2-ethylhexyl)phthalate (4 mg/L); 1,2-dichlorobenzene (54 mg/L); chromium (71 mg/L); and nickel (172 mg/L). With the exception of the occurrence of chromium (155 mg/L) in the sample from the middle of the stream at transect number 2, none of these chemicals were identified in samples collected at transects adjacent the site.

The leachate collected from this seep was obtained by excavating a shallow depression so that enough water would accumulate for sampling. In view of the necessary sampling procedure, it may be inferred that the flow rate of this seep is low. Thus, rapid dilution of the small quantities of chemicals that could be introduced to the river in this fashion is expected. Since these chemicals are volatile by nature, a substantial portion probably escape to the ambient air prior to reaching the river under these conditions. Dispersion and photolytic degradation is probably the ultimate fate of these chemicals.

Elizabeth River Samples

Several organic HSL chemicals were detected in the surface water samples from the river itself (transect samples). Tetrachloroethene (1.8 mg/L) was detected in a sample from the southern shore of the river at transect number 5. No HSL organic chemicals were detected in the sample obtained close to the groundwater discharge point (see Figures 4-11 through 4-14) near transect number 4. Aldrin (maximum concentration = 0.81 mg/l) and some PCBs (maximum concentration, total PCBs = 82 mg/L) were also detected. These chemicals were detected at the two transects furthest upstream. Since it is not believed that erosion will occur (because of the gravel fill), and since groundwater will not transport these highly soil-adsorptive

chemicals, it is believed that these substances came from a location upstream of the site.

Volatile organic chemicals were detected in groundwater and leachate samples. Thus it is concluded that contaminants are reaching the river. However, although volatile organic chemicals are being released to the river, no impact above instrument detection levels is discernible in the river itself.

Although no site-related impact is evident it is apparent that the water quality of the Elizabeth River is poor. A number of volatile, and several semi-volatile chemicals were detected in surface water samples collected from the Elizabeth River during the May 1986 sampling round. Acetone was detected at a concentration of 92 $\mu\text{g/l}$ in a sample collected at station 9, approximately 4,800 feet upstream of the site. Benzene was detected at a maximum concentration of 2.2 $\mu\text{g/l}$ in a sample from station 13, 3,200 feet upstream of the site. Toluene was detected in several samples and attained a maximum concentration of 14 $\mu\text{g/l}$ at station 7, 5,600 feet upstream of the site. 1,1,1-trichloroethane was detected in several samples and attained a maximum concentration of 6.3 $\mu\text{g/l}$ at station 10, 5,200 feet upstream of the site. Tetrachloroethene (PCE) was the organic compound detected most frequently in surface water samples from the Elizabeth River. The greatest PCE concentrations (14 $\mu\text{g/l}$ to 30 $\mu\text{g/l}$) were detected in samples from stations 9 through 13. Several additional volatile organics, including trichloroethene, 1,2-dichloroethene, and chloroform, were also detected in surface water samples. No trend suggesting that the Chemical Control Corporation Site is the source of this volatile organic contamination is evident from these data.

Numerous surface water samples from the Elizabeth River contained low levels of phthalate esters (i.e., concentrations of bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, and butyl benzyl phthalate on the order of instrument detection limits of 5 $\mu\text{g/l}$). A sample collected at station 19 (approximately 800 feet upstream of the site) contained di-n-butyl phthalate at a concentration of 460 $\mu\text{g/l}$.

Chlordane was identified in three surface water samples collected from upstream locations. Chlordane concentrations ranged from 0.59 to 0.77 $\mu\text{g/l}$. Low levels of polynuclear aromatic hydrocarbon (i.e., less than 5 $\mu\text{g/l}$) were detected in upstream samples. No evidence that the Chemical Control Corporation Site is the source of the semi-volatiles and pesticides is offered by the analytical results for the Elizabeth River surface water samples.

A number of inorganic substances were also detected in upstream surface water samples. Concentrations of toxic metals such as chromium, nickel, and lead attained their highest concentrations at locations well upstream of the site.

Manhole Samples

Complete analytic results for water samples collected from storm sewer manholes are included in Appendix A. Manhole sampling locations are depicted in Figure A-1 (Appendix A). Low levels of volatile organic chemicals (less than 5 µg/l) were detected in a number of the manhole samples. Chemicals detected include 1,1,1-trichloroethane, trichloroethene, 1,2-dichloroethene, carbon tetrachloride, and chloromethane. Ethylbenzene and xylenes were also detected in manhole samples, at concentrations ranging to 12 and 50 µg/l, respectively.

The storm sewer system is laid out such that water flows in a generally westerly direction from manhole number 1 to manhole number 4. The storm sewer system adjacent the site joins with a branch passing upstream properties between manholes 5 and 6.

Based on the presence of volatile organic chemicals in the sample from manhole number 4, it is apparent that contaminants such as halogenated alkanes and alkenes may be migrating from the site. Volatile chemicals may be migrating to the storm sewer system via a sanitary sewer line which extends from the center of the site to manhole number 2. Toluene and xylenes were detected at the highest concentrations in samples from manholes 5 and 6. These results are thought to reflect the presence of aromatic hydrocarbon sources upstream of the site since they were detected in a sample from the branch line (manhole number 5) or in a sample downstream of the junction of the branches (manhole number 6). Various polynuclear aromatic hydrocarbons were detected at low levels (less than 5 µg/l) in the sample collected from manhole number 6. PCB 1260 was also detected in this sample at a concentration of 3.5 µg/l. The source of these contaminants cannot be identified based on the available data. The sample from manhole number 7 (the manhole closest the sewer line outfall at the Arthur Kill) contained 1,1,1-trichloroethane (2 µg/l) and 1,2-dichloroethene (2 µg/l).

Various inorganic chemicals were also detected in manhole samples. Lead was identified in the sample from manhole number 4 at a concentration of 567 µg/l. Arsenic was detected at a maximum concentration of 8 µg/l in the sample from manhole number 5. Chromium and nickel were detected at maximum concentrations of 703 and 344 µg/l in the sample from manhole number 7. Based on the available data it is difficult to identify the source of this inorganic contamination. Only the lead results appear to suggest that Chemical Control Corporation Site is the source. However, since the storm sewer receives runoff from the roads in the area, the lead may be present as a result of deposition of exhaust from engines fired with leaded gasoline. Chromium and nickel were detected in groundwater samples collected from the site, and these substances may have migrated from the site to the storm sewer system via the sanitary sewer line.

5.3 SEDIMENT INVESTIGATION

5.3.1 Methods of Investigation

Sediment samples were taken along six transects during the December 1985 sampling round. Separate surface sediment samples (0-6 inches) and deep sediment samples (0-24 inches) were taken at three locations along each transect. The locations were approximately one-quarter, one-half, and three-quarters of the way across the river from the south bank. Transects 001, 004, 005, and 006 were sampled as the tide was going out, while transects 002 and 003 were sampled as the tide was coming in. Tabulations of the analytical results are presented in Appendix A.

The surface sediment samples represent a composite of the top six inches of sediment. The samples were obtained with a ponar dredge. The deep sediment samples represent a composite of the top 24 inches of sediment. These samples were taken with a stainless steel corer that was driven into the river substrate. There was poor recovery of the deep sediment samples from transect 006, at the mouth of the Elizabeth River near the Arthur Kill, because of the coarse sandy material in the substrate.

Additional sediment samples were collected from the Elizabeth River and the Arthur Kill during the May 1986 sampling round. Sediment samples were composite samples of 1 to 3 feet of sediment and were obtained using a stainless steel sampling tube where possible. A ponar dredge was used to obtain surface sediments where deeper samples could not be obtained as a result of refusal.

Twenty-three midstream sediment samples were collected from the Elizabeth River at 400-foot intervals. Sample locations ranged from the confluence of the Arthur Kill and Elizabeth River to a point approximately 2 miles upstream of the site. Sampling locations are presented in Drawing S769-49-01 (included in the back pocket of this report). Four sediment samples were also collected from the Arthur Kill, near the chemical Control Corporation site shoreline. Sediment samples were collected in the suspected vicinity of the storm sewer outfall, near the mouth of the Elizabeth River, and at a location between these locations.

5.3.2 Results of Investigation - Physical System

The sediments were characterized primarily as black silts. Leaves and other organic debris were commonly found in the surface samples. In many locations an oily sheen was seen on the sediments, and at one location (transect 001, core, one-half across the river) sampling personnel reported an organic vapor smell which they characterized as naphthalene. Core

samples from transect 003 encountered material similar to the organic clays and silts found on site in the drilling program. Some of the other transects found clays at depth in the core samples.

5.3.3 Results of Investigation - Extent of Contamination

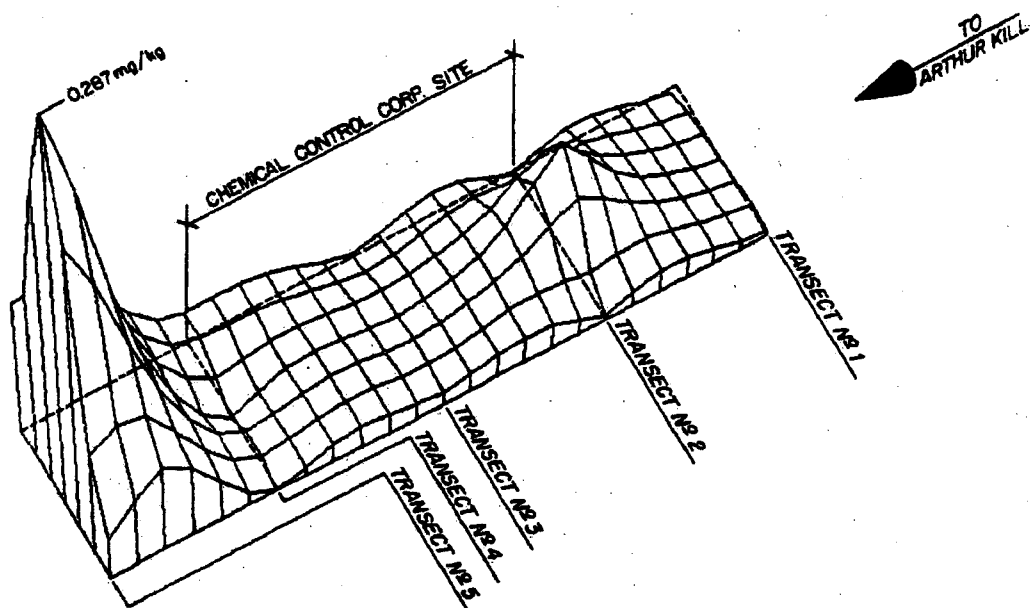
Numerous organic and inorganic HSL chemicals were detected in the sediment samples. For the most part the analytical results indicate that the river has been impacted by upstream sources.

Figures 5-1 and 5-2 provide schematic representations of the analytical results for two general chemical classes detected in sediment transect samples from the December 1985 sampling program. The figures reveal that concentrations of these chemicals increase fairly dramatically just downstream of the site, on the southern (Chemical Control) side of the river. Note, however, that the PAH results for core sediments do not follow this trend. The core results may indicate the presence of upstream sources.

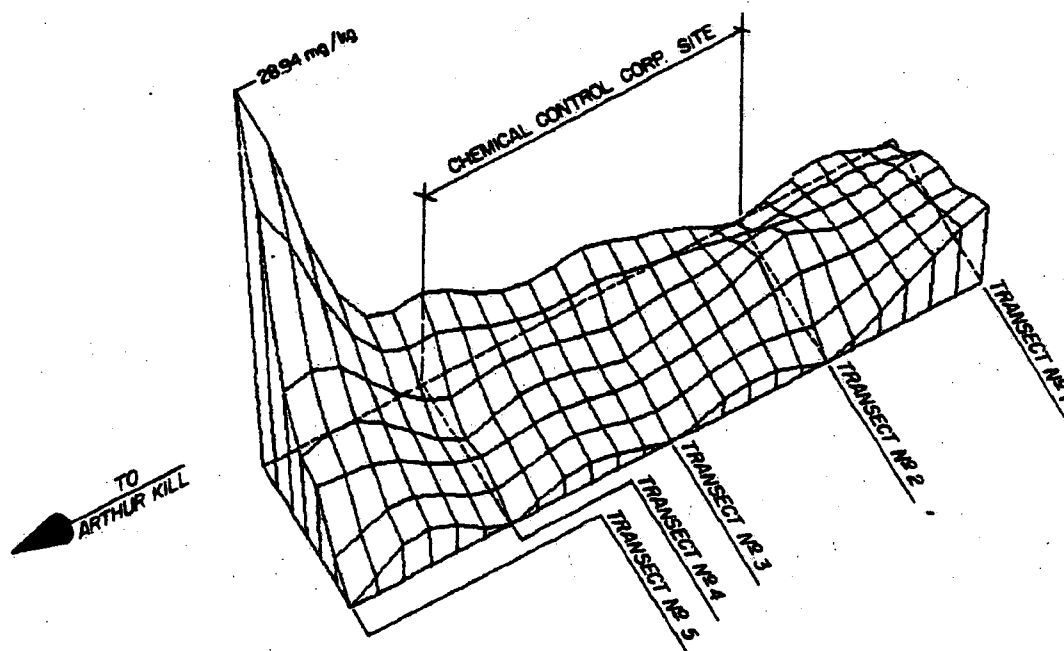
Figure 5-1 includes results for total monocyclic aromatics. Concentrations of these chemicals are higher in the core samples than in the surface samples. This could be a result of either diffusion of the organic compounds into the water column at the sediment/surface water interface or because the volatile-contaminated sediments (core samples) were laid down at an earlier date.

Figure 5-2 presents results for total polynuclear aromatic hydrocarbons. Evidence of possible site-related impact is most notable in the surface sediment samples which display a trend similar to that of the monocyclic aromatic compounds. However, the highest concentrations of PAHs were detected in a core sediment sample collected upstream of the site (at transect number 1). The occurrence of PAHs at this location is probably attributable to upstream industrial sources.

Review of the more extensive sediment data collected during May 1986 provides evidence that the contamination identified in sediment samples from the Elizabeth River may have originated from alternate sources. Analytical results for May 1986 sediment samples indicate that PAHs are present along the entire length of the Elizabeth River. Volatile organics were identified in a number of samples but achieved higher concentrations of station 12 (3,600 feet upstream of the site). Monocyclic aromatics were detected in sediment samples collected from station 18 (1,200 feet upstream of the site) to station 24 (at the mouth of the Elizabeth River. These compounds (ethylbenzene, toluene, and xylenes) are familiar components of gasoline or other petroleum products. The presence of these compounds in sediment samples, and the absence of many of the chlorinated aliphatic site contaminants, suggests that these compounds originated from an alternate source. The same



TOTAL MONOCYCLIC AROMATICS IN SURFACE SEDIMENTS

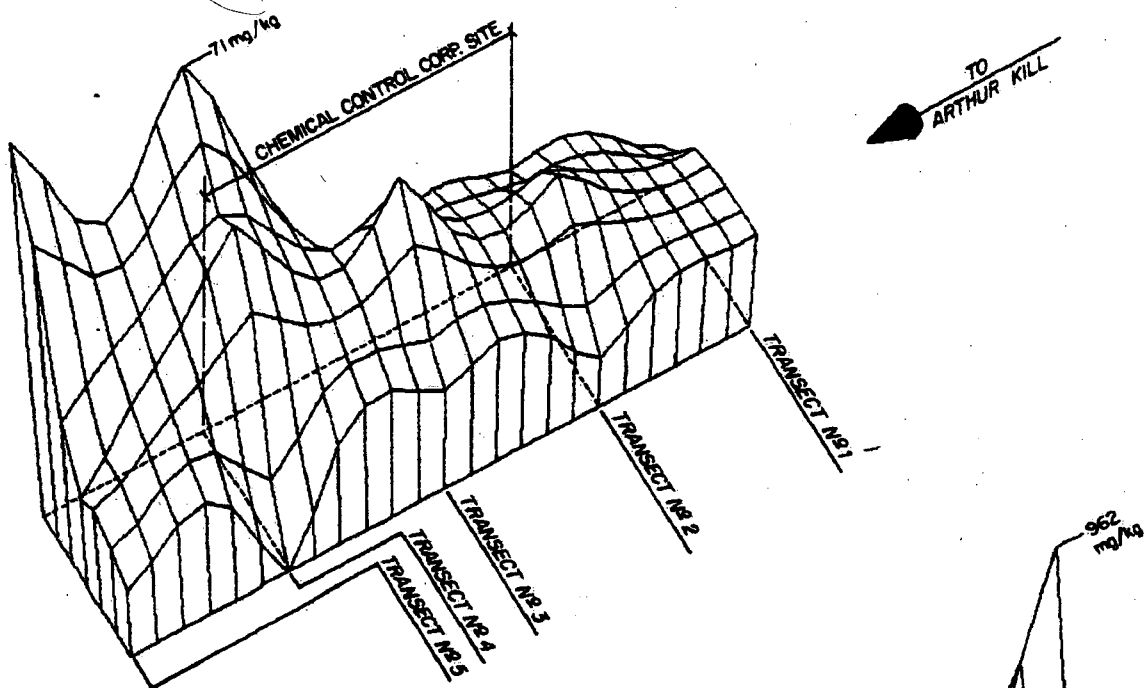


TOTAL MONOCYCLIC AROMATICS IN CORE SEDIMENTS

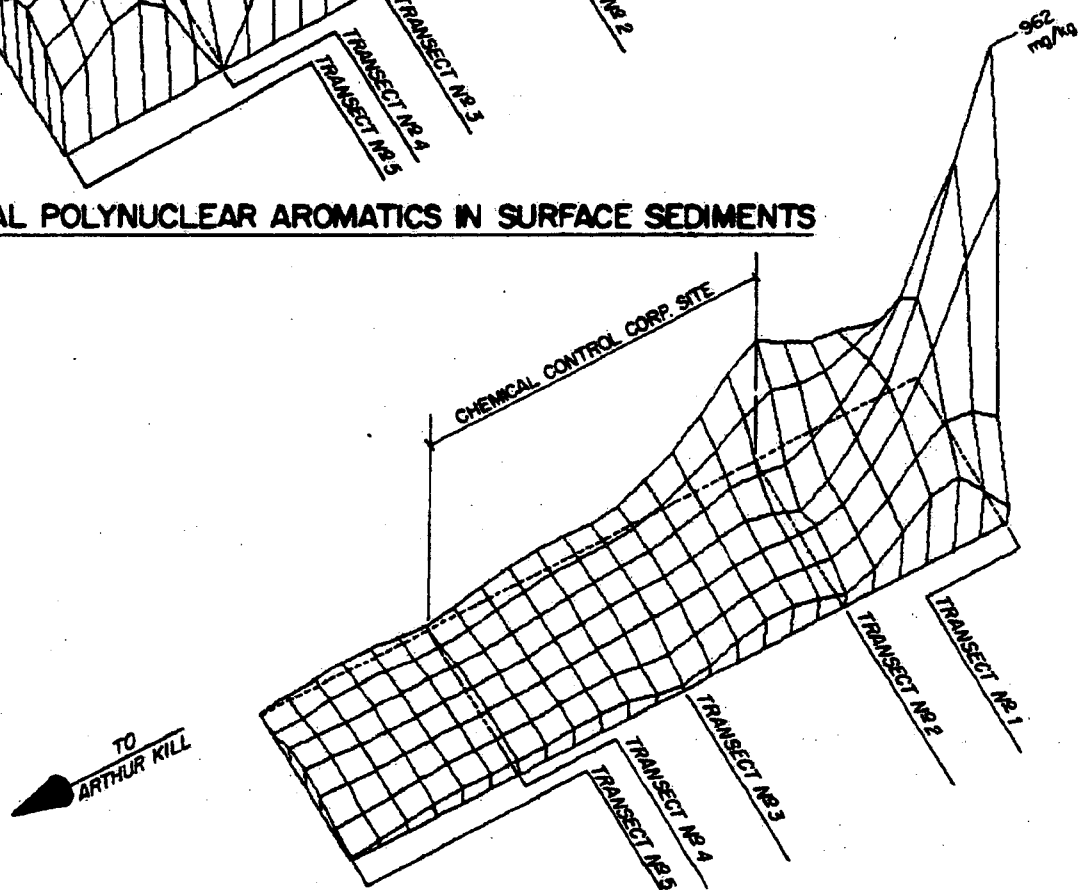
TOTAL MONOCYCLIC AROMATIC CONCENTRATIONS
IN ELIZABETH RIVER SEDIMENT SAMPLES
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ
 NOT TO SCALE

FIGURE 5-1





TOTAL POLYNUCLEAR AROMATICS IN SURFACE SEDIMENTS



TOTAL POLYNUCLEAR AROMATICS IN CORE SEDIMENTS

TOTAL POLYNUCLEAR AROMATIC CONCENTRATIONS
IN ELIZABETH RIVER SEDIMENT SAMPLES
CHEMICAL CONTROL CORP. SITE, ELIZABETH, N.J
 NOT TO SCALE

FIGURE 5-2



compounds (toluene, ethylbenzene, xylenes, and polynuclear aromatic hydrocarbons) were also identified in sediment samples from the Arthur Kill, an environmental receptor with which the Chemical Control Corporation site has a less direct link.

5.4 SUMMARY OF SURFACE WATER INVESTIGATION

5.4.1 Summary of Physical System

The Elizabeth River occasionally reaches a sufficient stage to inundate the site as a result of a variety of influences. This inundation provides a "slug" of recharge to the shallow groundwater system which slowly drains off through time as discussed in the groundwater section. Under non-overbank high tide events, the river has little effect on the groundwater flow in the shallow groundwater zone.

The sediments in the river substrate are primarily black silts. At some locations the sediments are thin and cores revealed materials similar to the silts and clays found on site.

5.4.2 Transport Mechanisms and Contaminant Migration

The groundwater investigation established that the Elizabeth River is probably the main receiving body for groundwater discharge off the site. Only two seeps were observed along the river bank bordering the site. Therefore it is assumed that the majority of the groundwater enters the river through subsurface seepage.

The amount of groundwater entering the river from the site varies. Immediately following the site flood in December 1985 the calculations showed a maximum of 49,000 gpd of groundwater discharging from the site, with the discharge for the first week following the flood averaging 16,000 gpd. Under more normal circumstances, the groundwater discharge into the river is estimated to be 640 gpd.

This groundwater discharge is diluted by the river. The gaging station data established an average minimum daily mean flow rate for the last four years upstream from the site of 3.85 cfs, or approximately 2.5 million gpd (i.e., an average value of the minimum daily mean flow rates for the 4 year period).

The impact of contaminated groundwater discharge to the Elizabeth River was discussed in Section 4.6.3. The analysis indicated only limited potential impact, even under worst-case conditions. Surface water samples from the Elizabeth River indicate no impact attributable to chemical contamination at the site. Residual contaminants in the sediment samples will probably slowly degrade or ultimately disperse into the Arthur Kill.

6.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

6.1 INTRODUCTION

This section discusses the risks to human and environmental receptors posed by chemical contaminants at or originating from the Chemical Control Site. To assess these risks, three major aspects of the chemical contamination and environmental fate and transport of site chemicals must be considered.

- The potential for human or environmental exposure to site chemicals and the concentrations to which the receptors may be exposed.
- The carcinogenic and non-carcinogenic health hazards associated with the organic and inorganic chemicals detected at the site.
- The risks associated with exposure to chemicals at the concentrations identified above as compared with applicable regulatory enforceable standards or guidelines for the protection of human or environmental receptors.

The basis for this risk assessment is the validated chemical-analytical data base for environmental samples collected during the NUS Corporation Remedial Investigation (1985-1986).

The remainder of this section is structured to follow an assessment approach suggested by the United States Environmental Protection Agency (EPA) (49 Federal Register 227, 46294 et seq.). The approach consists of the four components listed below.

- Hazard Identification
- Dose-Response Evaluation
- Exposure Assessment
- Risk Characterization

Hazard identification (Section 6.2) is primarily concerned with the selection of chemical contaminants ("indicator chemicals") that are representative of the human health and/or environmental impacts associated with wastes at the site. Contaminant concentrations, contaminant release, environmental transport and exposure mechanisms, and toxicity are considered in order to reduce the complete list of site contaminants to a list of chemicals that will adequately define the associated risks. Qualitative discussions of human and animal acute, chronic, and/or non-threshold (carcinogenic) effects are presented for each of the selected indicator chemicals.

The dose-response evaluation (Section 6.3) presents available human health and environmental impact information for the

indicator chemicals. For noncarcinogens, quantitative toxicity indices are presented, including regulatory standards and criteria that define "acceptable" levels of exposure. Enforceable standards such as Maximum Contaminant Levels (MCLs) or regulatory guidelines such as Ambient Water Quality Criteria (AWQC), Acceptable Daily Intakes (ADIs), or Suggested No Adverse Response Levels (SNARLs) are used to characterize the toxic effects associated with the chemicals detected at the site. Carcinogenic potency indices (or AWQC, when applicable) are used to estimate the risks associated with carcinogenic substances present in site media.

The exposure assessment (Section 6.4) is based on source contaminant concentrations, contaminant release mechanisms based on relevant hydrologic and hydrogeologic information, and other pertinent information such as land and water use or demographic information. Potential human and animal exposures to contaminants at the source or offsite are identified in this section.

In the context of this report "exposure assessment" includes not only receptor exposure mechanisms such as inhalation, ingestion, and dermal contact, but also migration of chemicals via environmental transport routes. The environmental fate and transport of indicator chemicals is discussed in this section, relying on information such as environmental "mobility parameters", degradation mechanisms, and site-specific chemical analytical results. The analytical results presented in Sections 4.0 and 5.0 and associated discussion should be reviewed as necessary since this information is of paramount importance to the exposure assessment. Quantitative, semi-quantitative, or qualitative estimates of exposure duration and concentrations are made in this section.

Risk characterization (Section 6.5) contrasts the exposure concentrations predicted in Section 6.4 to MCLs, AWQC, or other relevant regulatory standards or guidelines (Section 6.3) to define the risks associated with threshold (non-carcinogenic) effects of chemicals identified in various site media. Estimates of carcinogenic risk associated with individual chemicals and mixtures of site chemicals will be presented in this section, based on the carcinogenic potency indices (or on the AWQC when these criteria are based on human carcinogenicity).

6.1.1 Limitations in the Risk Assessment Process

Certain limitations are inherent to the exposure/risk assessment process. Factors limiting the extent to which the human and environmental health risks can be characterized are primarily associated with the estimation of toxicity and include various uncertainties in the toxicologic data base. Extrapolation of non-threshold (carcinogenic) effects from high to low doses, variance in endpoints used for determination of potential health

effects, extrapolation of the results of animal studies to human receptors, varying sensitivity between individuals, and other uncertainties make definite characterization of health risks infeasible. Because of these limitations, "uncertainty factors" are generally incorporated into the regulatory toxicological indicators (MCLs, ADIs, etc.) to ensure that, while they may overestimate the risks, they do not underestimate them.

6.2 HAZARD IDENTIFICATION

Table 6-1 summarizes the occurrence and distribution of HSL organic and inorganic chemicals detected in various environmental media (i.e., soil, surface water, sediment, and groundwater) sampled at the Chemical Control Site. Included in the table are the frequency of occurrence and media-specific concentration ranges for each of the chemicals identified. This table was compiled using the analytical results for samples collected by NUS, which were validated by EPA Region II. This table provides the basis for selection of the indicator chemicals.

The table reveals that numerous HSL organic and inorganic chemicals were detected at the site. The remainder of this section is primarily concerned with reducing the complete list of chemicals (Table 6-1) to an abridged list which will adequately characterize the carcinogenic and non-carcinogenic risks to human and environmental receptors. Human health impacts associated with each of the indicator chemicals (toxicity profiles) are included in Appendix F since numerous chemicals are included and the text is quite lengthy. Indicator chemicals selected for the Chemical Control Site are summarized in Table 6-2. The rationale for inclusion or deletion of specific site contaminants is discussed below.

6.2.1 Volatile Indicator Chemical Selection

Volatile chemicals representing various general chemical classes including monocyclic aromatics (e.g., benzene, toluene, ethylbenzene), halogenated alkanes (e.g., 1,1,-dichloroethane, 1,2-dichloroethane), halogenated alkenes (e.g., trichloroethene, vinyl chloride), ketones (e.g., acetone, 2-butanone), and halomethanes (e.g., chloroform, methylene chloride) were detected in samples collected at the Chemical Control Site. In view of the environmental mobility of these chemicals (through atmospheric, surface water, and groundwater transport) virtually all of the volatile chemicals detected at the site have been retained as indicator chemicals. The following exceptions are made in this respect:

- 4-methyl-2-pentanone (maximum concentration (C_{max}) = 2.7 ppm) - This substance was detected less frequently and at much lower concentrations than the ketones retained as indicator chemicals (acetone, C_{max} = 750 ppm and 2-butanone, C_{max} = 500 ppm).

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985

CAS Number	Chemical (CRDL)	Groundwater Samples (20 Total)		Surface Water Samples (11 Total)		Sediment Samples (36 Total)	
		No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/
	<u>Volatile</u>						
67-64-1	acetone (10)	4	110 - 280			31	25 - 870
78-93-3	2-butanone (10)	1	13			10	20 - 340
108-10-1	4-methyl-2-pentanone (10)	4	6 - 170				
71-43-2	benzene (5)	4	8 - 38			20	4 - 640
108-88-3	toluene (5)	8	5 - 120			19	4 - 6,000
100-41-4	ethylbenzene (5)	7	2 - 54			23	4.2 - 4,300
	total xylenes (5)	11	3 - 90			23	6 - 13,000
100-42-5	styrene (5)	1	20				
108-90-7	chlorobenzene (5)	2	4 - 5			22	2 - 5,000
79-34-5	1,1,2,2-tetrachloroethane (5)						
71-55-6	1,1,1-trichloroethane (5)						
75-34-3	1,1-dichloroethane (5)	1	13				
107-06-2	1,2-dichloroethane (5)	5	2 - 47				
75-00-3	chloroethane (10)						
127-18-4	tetrachloroethene (5)	8	2 - 64	1	1.8	1	15
79-01-6	trichloroethene (5)	9	4 - 110	1	300	1	15
156-60-5	1,2-dichloroethene (5)	9	3 - 820	1	2,100	1	15
75-01-4	vinyl chloride (10)	7	6-190	1	600		
56-23-5	carbon tetrachloride (5)						
67-66-3	chloroform (5)	7	5 - 42			5	3.1 - 7.6
75-09-2	methylene chloride (5)	7	2 - 85			15	10 - 180
74-87-3	chloromethane (10)						
74-83-9	bromomethane (10)						
75-15-0	carbon disulfide (5)	1	3			7	3.7 - 23

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
PAGE TWO

CAS Number	Chemical (CRDL)	Subsurface Soil Samples (27 Total)		Surface Soil (16 Total)		Gravel Samples (10 Total)	
		No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/
	<u>Volatile</u>						
67-84-1	acetone (10)	7	160 - 750,000				
78-93-3	2-butanone (10)	9	25 - 500,000				
108-10-1	4-methyl-2-pentanone (10)	8	8.5 - 2,700				
71-43-2	benzene (5)	13	3 - 3,800				
108-88-3	toluene (5)	21	1.2 - 2,800				
100-41-4	ethylbenzene (5)	14	7 - 3,100				
	total xylenes (5)	15	2.7 - 5,500				
100-42-5	styrene (5)	4	45 - 3,600				
108-90-7	chlorobenzene (5)	7	3.4 - 270				
79-34-5	1,1,2,2-tetrachloroethane (5)	1	20				
71-55-6	1,1,1-trichloroethane (5)	2	7.4 - 110				
75-34-3	1,1-dichloroethane (5)	1	350				
107-08-2	1,2-dichloroethane (5)	3	170 - 2,000				
75-00-3	chloroethane (10)	1	280				
127-18-4	tetrachloroethene (5)	14	3.7 - 1,400				
79-01-6	trichloroethene (5)	11	4 - 32,000				
156-80-5	1,2-dichloroethene (5)	10	4 - 15,000				
75-01-4	vinyl chloride (10)	6	3 - 250				
56-23-5	carbon tetrachloride (5)						
67-86-3	chloroform (5)	12	3.1 - 1,700				
75-09-2	methylene chloride (5)	9	34 - 630,000				
74-87-3	chloromethane (10)	1	250				
74-83-9	bromomethane (10)	1	160				
75-15-0	carbon disulfide (5)	14	1.6 - 130				

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
PAGE THREE

CAS Number	Chemical (CRDL)	Groundwater Samples (20 Total)		Surface Water Samples (11 Total)		Sediment Samples (36 Total)	
		No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/k)
Acid Extractables							
108-95-2	phenol (10/330)						
95-48-7	2-methylphenol (10/330)	1	4				
106-44-5	4-methylphenol (10/330)						
105-67-9	2,4-dimethylphenol (10/330)					1	1,700
Base/Neutral Extractables							
117-81-7	bis(2-ethylhexyl)phthalate (10/330)	4	4 - 100	1	4	35	6,000 - 42,000
117-84-0	di-n-octyl phthalate (10/330)	2	2 - 4			22	260 - 1,200
84-74-2	di-n-butyl phthalate (10/330)	2	2 - 23			24	120 - 13,000
84-66-2	diethyl phthalate (10/330)	2	4 - 5				
85-68-7	butylbenzyl phthalate (10/330)					10	340 - 7,100
131-11-3	dimethyl phthalate (10/330)						
83-32-9	acenaphthene (10/330)					27	110 - 27,000
208-96-8	acenaphthylene (10/330)					20	110 - 2,200
120-12-7	anthracene (10/330)					26	230 - 16,000
56-55-3	benzo(a)anthracene (10/330)					33	380 - 13,000
205-99-2	benzo(b)fluoranthene (10/330)					28	750 - 13,000
207-08-9	benzo(k)fluoranthene (10/330)					27	750 - 13,000
191-24-2	benzo(g,h,i)perylene (10/330)	1	2			12	230 - 1,700
50-32-8	benzo(a)pyrene (10/330)	2	2 - 8			28	440 - 7,300
218-01-9	chrysene (10/330)					33	580 - 12,000
53-70-3	dibenz(a,h)anthracene (10/330)	1	2			1	220
206-44-0	fluoranthene (10/330)					35	1,200 - 35,000
86-73-7	fluorene (10/330)					12	140 - 21,000
193-39-5	indeno(1,2,3-cd)pyrene (10/330)	1	2			14	170 - 1,400
91-20-3	naphthalene (10/330)	2	2 - 4			27	110 - 51,000
91-57-6	2-methylnaphthalene (10/330)					21	180 - 27,000
85-01-8	phenanthrene (10/330)					34	500 - 61,000
129-00-0	pyrene (10/330)					35	1,100 - 22,000

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
PAGE FOUR

CAS Number	Chemical (CRDL)	Subsurface Soil Samples (27 Total)		Surface Soil (18 Total)		Gravel Samples (10 Total)	
		No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/kg)
<u>Acid Extractables</u>							
108-95-2	phenol (10/330)	6	800 - 4,800				
95-48-7	2-methylphenol (10/330)	2	500 - 680				
106-44-5	4-methylphenol (10/330)	7	94 - 6,000				
105-67-9	2,4-dimethylphenol (10/330)	3	60 - 720				
<u>Base/Neutral Extractables</u>							
117-81-7	bis(2-ethylhexyl)phthalate (10/330)	16	54 - 15,000				
117-84-0	di-n-octyl phthalate (10/330)	3	51 - 1,300				
84-74-2	di-n-butyl phthalate (10/330)	4	49 - 25,000				
84-68-2	diethyl phthalate (10/330)						
85-68-7	butylbenzyl phthalate (10/330)	3	1,900 - 6,000				
131-11-3	dimethyl phthalate (10/330)	1	990				
83-32-9	acenaphthene (10/330)	5	40 - 760				
208-96-8	acenaphthylene (10/330)	1	320				
120-12-7	anthracene (10/330)	5	79 - 1,300				
56-55-3	benzo(a)anthracene (10/330)	12	51 - 2,500				
205-99-2	benzo(b)fluoranthene (10/330)	7	66 - 3,100				
207-08-9	benzo(k)fluoranthene (10/330)	11	57 - 3,100				
191-24-2	benzo(g,h,i)perylene (10/330)	4	40 - 770				
50-32-8	benzo(a)pyrene (10/330)	10	47 - 2,000				
218-01-9	chrysene (10/330)	8	51 - 2,200				
53-70-3	dibenz(a,h)anthracene (10/330)	1	350				
206-44-0	fluoranthene (10/330)	15	60 - 5,300				
86-73-7	fluorene (10/330)	4	44 - 850				
193-39-5	indeno(1,2,3-cd)pyrene (10/330)	5	40 - 750				
91-20-3	naphthalene (10/330)	9	62 - 1,600				
91-57-8	2-methylnaphthalene (10/330)	5	49 - 800				
85-01-8	phenanthrene (10/330)	15	66 - 6,000				
129-00-0	pyrene (10/330)	12	100 - 4,100				

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
PAGE FIVE

CAS Number	Chemical (CRDL)	Groundwater Samples (20 Total)		Surface Water Samples (11 Total)		Sediment Samples (36 Total)	
		No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/k)
Base/Neutral Extractables							
95-50-1	1,2-dichlorobenzene (10/330)	2	4 - 18	1	54	2	620 - 10,000
541-73-1	1,3-dichlorobenzene (10/330)					2	110 - 510
106-46-7	1,4-dichlorobenzene (10/330)					10	95 - 7,100
120-82-1	1,2,4-trichlorobenzene (10/330)						
88-30-8	n-nitrosodiphenylamine (10/330)					1	400
106-47-8	4-chloroaniline (10/330)					4	300 - 4,200
65-85-0	benzoic acid (50/1600)						
100-51-6	benzyl alcohol (10/330)						
111-91-1	bis(2-chloroethoxy)methane (10/330)						
132-64-9	dibenzofuran (10/330)					18	100 - 13,000
78-59-1	isophorone (10/330)						

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
PAGE SIX

CAS Number	Chemical (CRDL)	Subsurface Soil Samples (27 Total)		Surface Soil (10 Total)		Gravel Samples (10 Total)	
		No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/k
<u>Base/Neutral Extractables</u>							
95-50-1	1,2-dichlorobenzene (10/330)	5	40 - 1,000				
541-73-1	1,3-dichlorobenzene (10/330)						
106-46-7	1,4-dichlorobenzene (10/330)						
120-82-1	1,2,4-trichlorobenzene (10/330)	3	80 - 590				
86-30-6	n-nitrosodiphenylamine (10/330)	2	80 (both)				
106-47-8	4-chloroaniline (10/330)						
65-85-0	benzoic acid (50/1600)	1	380				
100-51-6	benzyl alcohol (10/330)	2	80 - 630				
111-91-1	bis(2-chloroethoxy)methane (10/330)	1	94				
132-64-9	dibenzofuran (10/330)	2	290 - 740				
78-59-1	isophorone (10/330)	2	230 - 1,700				

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
PAGE SEVEN

CAS Number	Chemical (CRDL)	Groundwater Samples (28 Total)		Surface Water Samples (11 Total)		Sediment Samples (36 Total)	
		No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/k)
<u>Pesticides/PCBs</u>							
319-84-6	alpha-BHC (0.05/8.0)	1	0.15				
50-29-3	4,4'-DDT (0.10/16.0)					18	19 - 970
74-54-8	4,4'-DDD (0.10/16.0)					27	20 - 420
72-55-9	4,4'-DDE (0.10/16.0)	2	0.041 - 0.28			27	17 - 340
1031-07-8	endosulfan sulfate (0.10/16.0)	1	0.36				
60-57-1	dieldrin (0.10/16.0)					1	210
53469-21-9	Arochlor 1242 (0.5/80.0)					1	5,100
11097-89-1	Arochlor 1254 (1.0/160.0)					1	440
11096-82-5	Arochlor 1260 (1.0/160.0)					1	5,200

TABLE 6-1
 OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
 BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
 PAGE EIGHT

CAS Number	Chemical (CRDL)	Subsurface Soil Samples (27 Total)		Surface Soil (16 Total)		Gravel Samples (10 Total)	
		No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/kg)
	<u>Pesticides/PCBs</u>						
319-84-8	alpha-BHC (0.05/8.0)						
50-29-3	4,4'-DDT (0.10/16.0)	1	38				
74-54-8	4,4'-DDD (0.10/16.0)						
72-55-9	4,4'-DDE (0.10/16.0)	2	12 - 24				
1031-07-8	endosulfan sulfate (0.10/16.0)						
60-57-1	dieldrin (0.10/16.0)						
53469-21-8	Arochlor 1242 (0.5/80.0)						
11097-89-1	Arochlor 1254 (1.0/160.0)	7	40 - 973				
11096-82-6	Arochlor 1260 (1.0/160.0)	1	6,000				

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1983
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CAS Number	Chemical (CRDL)	Groundwater Samples (20 Total)		Surface Water Samples (11 Total)		Sediment Samples (36 Total)	
		No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/l)	No. of Occurrences	Concentration Range (mg/kg)
<u>Inorganics</u>							
7429-90-5	aluminum (200)	6	318 - 2,140	11	142 - 9,026	36	6,590 - 14,600
7440-38-0	antimony (60)	1	62			8	24 - 147
7440-38-2	arsenic (10)			6	15 - 25	31	14 - 73
513-77-9	barium (200)	14	111 - 1,080			36	117 - 465
100-44-7	beryllium (5)					36	0.63 - 2.1
7440-43-9	cadmium (5)					35	5.5 - 24
7440-70-2	calcium (5000)	20	48,100 - 284,000	11	129,000 - 208,000	36	2,630 - 11,200
7440-47-3	chromium (10)	1	23	2	71 - 155	36	93 - 385
7440-48-4	cobalt (50)	2	25 - 28			36	6.8 - 19
7440-50-4	copper (25)	1	24	4	19 - 122	36	188 - 647
1389-37-1	iron (100)	12	310 - 10,300	11	317 - 15,800	36	16,300 - 39,600
7439-92-1	lead (5)	4	5.4 - 105	1	14	36	280 - 942
7439-96-4	magnesium (5000)	20	734 - 820,000	11	381,000 - 512,000	36	4,920 - 8,890
7439-96-5	manganese (15)	18	101 - 2,054	11	58 - 565	36	169 - 400
7439-97-8	mercury (0.2)			3	0.10 - 0.16	36	1.5 - 12.3
7440-02-0	nickel (40)	6	27 - 647	2	172 - 193	36	41 - 140
7440-09-7	potassium (5000)	10	20,600 - 185,000	9	106,000 - 136,000	21	2,120 - 3,730
7782-49-2	selenium (5)					36	4.8 - 18
7440-22-4	silver (10)	5	12 - 41			36	5,510 - 13,400
7440-23-5	sodium (5000)	20	145,000 - 6,940,000	11	1,580,000 - 3,710,000		
7440-28-0	thallium (10)					35	19 - 99
7440-31-5	tin (40)			1	115	36	27 - 74
7440-62-2	vanadium (50)			1	131	36	271 - 1,180
7440-66-6	zinc (20)	8	22 - 90	2	146 - 266		
<u>SAS Analytes (10 Total)</u>							
	cyanide	6	13 - 137				
	Cl	10	218,000 - 12,500,000	11	4,320,000 - 10,100,000		
	SO ₄	9	140,000 - 1,300,000	11	388,000 - 1,270,000		
	CO ₃	1	292,000				
	Acidity	10	103,000 - 1,700,000	11	35,400 - 82,000		
	Alkalinity	10	103,000 - 1,870,000	11	78,000 - 390,000		
	NO ₃	1	570	1	1,250		
	HCO ₃	10	26,000 - 1,870,000	11	78,000 - 390,000		
	TSS	8	32,000 - 1,040,000	9	4,000 - 75,600		
	TDS	8	752,000 - 23,200,000	11	7,540,000 - 12,800,000		

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL CHEMICALS DETECTED AT THE CHEMICAL CONTROL SITE
BASED ON SAMPLES COLLECTED BY NUS CORPORATION, 1985
PAGE TEN

CAS Number	Chemical (CRDL)	Subsurface Soil Samples (27 Total)		Surface Soil (16 Total)		Gravel Samples (10 Total)	
		No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/kg)	No. of Occurrences	Concentration Range (mg/
<u>Inorganics</u>							
7429-90-8	aluminum (200)	27	1,780 - 19,600	16	5,900 - 12,100		
7440-38-0	antimony (60)			2	31 - 259		
7440-38-2	arsenic (10)	27	1.5 - 71	15	4.2 - 76		
513-77-9	barium (200)	21	37 - 347	15	54 - 276	9	1 - 46
100-44-7	beryllium (6)	26	0.35 - 1.3			10	0.2 - 0.4
7440-43-8	cadmium (5)	6	2.6 - 11	3	3.8 - 10	1	2.8
7440-70-2	calcium (5000)	21	1,140 - 14,000	16	1,620 - 15,600	9	752 - 33,930
7440-47-3	chromium (10)	27	3.6 - 85	16	10 - 78	10	3 - 4
7440-48-4	cobalt (50)	26	3.5 - 20	2	14 - 17		
7440-50-4	copper (25)	27	7.8 - 721	16	74 - 501	5	4 - 9
1309-37-1	iron (100)	27	2,570 - 42,000	16	18,800 - 47,800	1	60
7439-92-1	lead (5)	27	6.7 - 423	16	11 - 8,070		
7439-95-4	magnesium (5000)	21	825 - 9,670	16	744 - 6,020	10	136 - 5,894
7439-96-5	manganese (15)	27	42 - 723	16	101 - 526	10	10 - 188
7439-97-6	mercury (0.2)	17	0.12 - 2.46	16	0.19 - 2.1		
7440-02-0	nickel (40)	26	9.8 - 85	16	19 - 70		
7440-09-7	potassium (5000)	18	1,350 - 4,970	16	380 - 1,240		
7782-49-2	selenium (5)			2	2.9 - 3.7		
7440-22-4	silver (10)	15	2.2 - 8.8	3	4 - 41		
7440-23-5	sodium (5000)	10	456 - 12,600			10	511 - 10,030
7440-28-0	thallium (10)			1	136		
7440-31-6	tin (40)	6	22 - 65	12	15 - 258		
7440-62-2	vanadium (50)	26	12 - 69	16	21 - 80		
7440-66-6	zinc (20)	27	30 - 423	16	82 - 1,600	10	10 - 507
<u>SAS Analytes (10 Total)</u>							
	cyanide						
	Cl						
	SO ₄						
	CO ₃						
	Acidity						
	Alkalinity						
	NO ₃						
	HCO ₃						
	TSS						
	TDS						

TABLE 6-2
INDICATOR CHEMICALS
CHEMICAL CONTROL SITE

Carcinogenic Substances

benzene
1,2-dichloroethane
tetrachloroethene
trichloroethene
vinyl chloride
chloroform
methylene chloride
benzo(a)pyrene
4,4'-DDT
PCB 1260
N-nitrosodiphenylamine
chromium
arsenic
nickel

Non-carcinogenic Substances

bis(2-ethylhexyl)phthalate
1,2-dichlorobenzene
chlorobenzene
toluene
total xylenes
ethylbenzene
1,2-dichloroethene
lead
mercury
phenol
acetone
2-butanone

- 1,1,2,2-tetrachloroethane (Cmax = 0.25 ppm), 1,1,1-trichloroethane (Cmax = 0.35 ppm), bromomethane (Cmax = 0.16 ppm), and chloromethane (Cmax = 0.25 ppm) - These chemicals were each detected only in subsurface soil at the site, and only in one of the many samples collected. The low concentrations detected indicate that contaminant release to the groundwater should not comprise an environmental transport mechanism (none of these chemicals were detected in groundwater samples).
- Carbon disulfide - this chemical was detected only at low concentrations in environmental media at the site. Furthermore, only very limited information regarding the toxicity of this substance is available; no regulatory standards or guidelines are available regarding carbon disulfide.

All the remaining volatile compounds have been retained as indicator chemicals.

6.2.2 Acid Extractable Indicator Chemical Selection

Acid extractable compounds are quite water soluble and environmentally mobile. The toxicity of the acid-extractable compounds (various phenols) detected in site media are adequately represented by phenol, therefore only phenol is retained as an indicator chemical.

6.2.3 Base/Neutral Extractable Indicator Chemical Selection

Selection of base/neutral extractable indicator chemicals is primarily based on the availability of toxicity data. Base/neutral extractable compounds detected at the site include various polynuclear aromatic hydrocarbons (PAHs) such as benzo(a)pyrene and naphthalene, phthalate esters such as bis(2-ethylhexyl)phthalate and di-n-butyl phthalate, and various chlorinated benzenes such as 1,2-dichlorobenzene and 1,2,4-trichlorobenzene.

Toxicity information is usually provided for PAHs in general, rather than for specific compounds. Risks attributable to the presence of these substances may be characterized by summing the individual concentrations and treating the PAHs as a class of chemicals. Benzo(a)pyrene is the PAH that has been most widely studied. Hence, a toxicity profile is presented for this substance and is considered representative of the remainder of the class.

Bis(2-ethylhexyl)phthalate (BEHP) was detected in the most types of environmental media at the site and at higher concentrations than other phthalate esters. Recent evidence indicates that carcinogenic effects may be attributable to human exposure to

this chemical. Therefore BEHP has been selected as the best representative of the toxicity of this class of compounds.

Toxicity information presented in the literature is similar for the ortho, meta, and para isomers of dichlorobenzene. Therefore the isomer detected at the highest concentrations (1,2-dichlorobenzene) has been selected as the indicator chemical for this class of compounds.

In addition, N-nitrosodiphenylamine has also been included in the list of indicator chemicals because of toxicological considerations.

6.2.4 Pesticide/PCB Indicator Chemical Selection

Several pesticide compounds and polychlorinated biphenyls (PCBs) were detected in various samples collected at the site. With the exception of 4,4'-DDT and its degradation products (4,4'-DDD and 4,4'-DDE) and the PCBs, these substances were identified infrequently and at low concentrations. 4,4'-DDT, its degradation products, and PCBs have been retained as indicator chemicals for this reason. Enforceable standards and regulatory guidelines for 4,4'-DDT apply to both the parent compound and its degradation products. Similarly, standards for PCBs apply to this chemical class in general. 4,4'-DDT and PCB 1260 have therefore been selected as the indicator chemicals for the pesticide and PCB class of compounds. The analysis of risks attributable to these chemicals are treated in a manner similar to the PAHs; individual concentrations are summed and risks are characterized using the total PCB and DDT/degradation product levels.

6.2.5 Inorganic Indicator Chemical Selection

Inorganic indicator chemicals were selected based on concentrations detected in surface water samples as contrasted to National Interim Primary Drinking Water Standards as well as toxicity. Inorganic substances detected at levels in excess of these standards include lead in groundwater at 105 mg/l and chromium in surface water at 155 mg/l.

Other toxic inorganics were included as indicator chemicals (arsenic, nickel, and mercury) because their highest concentrations were more than one standard deviation from the media-specific mean concentration.

6.3 DOSE-RESPONSE EVALUATION

This section presents available regulatory standards or guidelines for the indicator chemicals selected in the preceding section. Presently the only enforceable regulatory standards are the Maximum Concentration Levels (MCLs). However, MCLs have not been specified for the majority of the indicator chemicals. Therefore, only regulatory guidelines may be used for

comparative purposes to infer health risks and environmental impacts. Relevant regulatory guidelines include the Ambient Water Quality Criteria, Recommended Maximum Concentration Levels, Proposed Maximum Contaminant Levels, Acceptable Daily Intakes, Suggested No Adverse Response Levels, and carcinogenic potency indices. The methodology used to establish these finalized or proposed environmental criteria are summarized briefly below. A discussion of the implications and limitations of the dose-response relationships, and the derived regulatory criteria is also included.

Acceptable Daily Intake (ADI) - applies to prolonged human exposure to hazardous chemicals (i.e., chronic exposure), and is based solely on the non-carcinogenic effects of chemical substances. The ADI is usually expressed as an acceptable dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest-observed-adverse-effect-level (LOAEL) by an appropriate "uncertainty factor". NOAELs, etc., are determined from laboratory or epidemiological toxicity studies. The uncertainty factor (10, 100, or 1,000) is based on the availability of toxicity data: 10 is used if appropriate chronic human data are available; 100 is used if sufficient chronic animal data are available; and 1,000 is used if only sub-chronic animal data can be obtained. Thus the ADI incorporates the surety of the evidence for chronic human health effects. Note that even if applicable human data exist, the ADI (as diminished by the uncertainty factor), still maintains a margin of safety such that chronic human health effects are not underestimated. Thus, the ADI is an acceptable guideline for evaluation of risk, although the associated uncertainties preclude its use for precise risk quantitation.

Carcinogenic Potency Index (CPI) - is applicable for estimating the lifetime probability (assumed 70 year lifespan) of human receptors contracting cancer caused by exposure to known or suspected human carcinogens. This index is generally reported in (kg-day/mg) and is derived through an assumed low-dosage linear relationship and extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the upper 95 percent confidence limit.

Ambient Water Quality Criteria (AWQC) - are not enforceable regulatory guidelines, and are of primary utility in assessing acute and chronic toxic effects in aquatic organisms and for identifying human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and adverse carcinogenic and non-carcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), and from ingestion of water alone (2 liters/day). The AWQCs for protection of human health for carcinogenic substances are based on the EPA's specified incremental cancer risk range of one additional case of cancer

in an exposed population of 10 million to 100 thousand persons (i.e., the 10^{-7} to 10^{-5} range).

Maximum Contaminant Levels (MCLs/RMCLs/PMCLs) - MCLs are enforceable standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 year lifetime) of an average adult (70 kg) consuming 2 liters of water per day, but also reflect the technical feasibility of removing the contaminant. These enforceable standards also reflect the fraction of the toxicant expected to be adsorbed by the gastrointestinal tract. Recommended Maximum Contaminant Levels (RMCLs) are specified as zero for carcinogenic substances, based on the assumption of nonthreshold toxicity, and do not consider the technical or economic feasibility of achieving these goals. RMCLs are non-enforceable guidelines based entirely on health effects. Proposed Maximum Contaminant Levels (PMCLs) are MCLs that have been set as close to the RMCL as is considered technically and economically feasible, but have not been approved to date. These guidelines are also non-enforceable.

Suggested No Adverse Response Levels (SNARLS) - are guidelines developed by the EPA Office Of Drinking Water for non-regulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight of 10 kg) who consume 1 liter of water per day. SNARLS are generally available for acute (1 day), sub-chronic (10 day), and chronic (long-term) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, do not consider carcinogenicity.

Values of the available regulatory standards and guidelines are presented in Table 6-3. Table 6-3 presents values both for chemicals that are human or suspected human carcinogens and for chemicals having only non-carcinogenic effects. If the dose of a chemical exceeds these standards or guidelines, there is a good possibility of adverse health effects for the receptor. Expected doses of the chemicals are presented in Section 6.4.3.

6.4 EXPOSURE ASSESSMENT

6.4.1 Nature and Extent of Contamination

6.4.1.1 Alternate Sources of Contamination

An assessment of site-related impact on the surrounding environment is confounded by the highly-industrialized nature of the area. Several possible alternate point sources exist within the immediate vicinity of the site and along the length of the Elizabeth River, including a petroleum tank farm upstream of

TABLE 6-3

REGULATORY STANDARDS AND GUIDELINES FOR INDICATOR CHEMICALS
CHEMICAL CONTROL SITE
ELIZABETH, NEW JERSEY

CAS #	Chemical	Maximum Contaminant Level (ug/l)(1)(2)	Carcinogenic Potency Factor (kg day/mg)(3)	Acceptable Daily Intake (mg/day)(4)	Suggested No Adverse Response Level (ug/l)(5)	Ambient Water Quality Criteria (ug/l)(6)			
						Acute Exposure - Aquatic Organisms		For Protection of Human Health	
						Freshwater Life	Saltwater Life	Ingestion of Fish and Water	Ingestion of Fish Only
<u>Human or Suspected Human Carcinogens</u>									
71-43-2	benzene	0 (RMCL) 5 (PMCL)	2.9x10 ⁻² (w)	200	10-day: 230 Chronic: 70	5.3x10 ³	5.1x10 ³	0.66(10 ⁻⁶)	40.0(10 ⁻⁶)
107-06-2	1,2-dichloroethane	0 (RMCL) 5 (PMCL)	6.9x10 ⁻²	-	-	1.18x10 ⁵	1.13x10 ⁵	0.94(10 ⁻⁶)	243(10 ⁻⁶)
127-18-4	tetrachloroethane	-	6.0x10 ⁻²	-	1-day: 2,300 10-day: 175 Chronic: 20	5.28x10 ³	1.02x10 ⁴	0.8(10 ⁻⁶)	8.85(10 ⁻⁶)
79-01-6	trichloroethane	0 (RMCL) 5 (PMCL)	1.2x10 ⁻²	-	1-day: 2,000 10-day: 200 Chronic: 75	4.5x10 ⁴	2x10 ³	2.7(10 ⁻⁶)	80.7(10 ⁻⁶)
75-01-4	vinyl chloride	0 (RMCL) 1 (PMCL)	1.75x10 ⁻² (l)	-	-	-	-	2.0(10 ⁻⁶)	525(10 ⁻⁶)
67-66-3	chloroform	-	7.0x10 ⁻²	-	-	2.89x10 ⁴	-	0.19(10 ⁻⁶)	15.7(10 ⁻⁶)
75-09-2	methylene chloride	-	7.5x10 ⁻³	13	1-day: 13,000 10-day: 1,300 Chronic: 150	1.1x10 ⁴ (a)	1.2x10 ⁴ (a)	0.19(10 ⁻⁶)(a)	15.7(10 ⁻⁶)(a)
50-32-8	benzo(a)pyrene	-	11.5	-	-	-	300(b)	2.8x10 ⁻³ (10 ⁻⁶)(b)	3.11x10 ⁻² (10 ⁻⁶)(b)
88-30-6	N-nitrosodiphenylamine	-	4.92x10 ⁻³	-	-	5.85x10 ³ (c)	3.3x10 ³ (c)	4.9(10 ⁻⁶)	16.1(10 ⁻⁶)
50-29-3	4,4-DDT	-	0.34	-	-	1.1	0.13	2.4x10 ⁻⁵ (10 ⁻⁶)	2.4x10 ⁻⁵ (10 ⁻⁶)
11096-82-5	PCB 1260	-	4.34	-	1-day: 125 10-day: 12.5	2.0	10	7.9x10 ⁻⁴ (10 ⁻⁶)	7.9x10 ⁻⁵ (10 ⁻⁶)
7440-47-3	chromium (VI)	50 (NIPDWS)	41(w)	-	-	21	1,260	50	-
7440-38-2	arsenic	50 (NIPDWS)	15(l)	-	-	440	508	2.2x10 ⁻³ (10 ⁻⁶)	1.75x10 ⁻² (10 ⁻⁶)
7440-02-0	nickel	-	1.15(w)	-	-	19,300(d)	140	13.4	100

TABLE B-3
REGULATORY STANDARDS AND GUIDELINES FOR INDICATOR CHEMICALS
CHEMICAL CONTROL SITE
ELIZABETH, NEW JERSEY
PAGE TWO

CAS #	Chemical	Maximum Contaminant Level (ug/l)(1)(2)	Acceptable Daily Intake (mg/day)(4)	Suggested No Adverse Response Level (ug/l)(5)	Ambient Water Quality Criteria (ug/l)(6)			
					Acute Exposure - Aquatic Organisms		For Protection of Human Health	
					Freshwater Life	Saltwater Life	Ingestion of Fish and Water	Ingestion of Fish Only
<u>Non-Carcinogens</u>								
	toluene	-	30	1-day: 21,500 10-day: 2,200 Chronic: 340	1.75x10 ⁴	6.3x10 ³	1.43x10 ⁴	4.24x10 ⁵
	total xylenes	-	160	1-day: 12,000 10-day: 1,200 Chronic: 620				
	ethylbenzene	-	9.5	-	3.2x10 ⁴	430	1.4x10 ³	3.28x10 ³
	chlorobenzene	-	1.0	-	250(f)	180(f)	488	-
	1,2-dichlorobenzene	-	8.3	-	250(f)	180(f)	400	-
	1,2-dichloroethene	-	-	1-day: 2,700 10-day: 270	1.16x10 ⁴ (g)	2.24x10 ⁵ (g)	-	-
	acetone	-	200	-				
	2-butanone	-	1.4	10-day: 7,500 Chronic: 750	-	-	-	-
	phenol	-	7.0	-	1.02x10 ⁴	5.8x10 ³	3.5x10 ³	-
	bis(2-ethylhexyl)phthalate	-	42	-	940(h)	2.944x10 ³ (h)	1.5x10 ⁴	5.0x10 ⁴
	lead	50 (NPDWS)	-	-	7.5x10 ³ (d)	668	50	-
	mercury	2 (NPDWS)	-	-	1.7x10 ⁻³	3.7	0.144	0.148

TABLE 6-3
REGULATORY STANDARDS AND GUIDELINES FOR INDICATOR CHEMICALS
CHEMICAL CONTROL SITE
ELIZABETH, NEW JERSEY
PAGE THREE

Notes:

- (1) USEPA, March 4, 1982.
- (2) USEPA, November 13, 1985 (a-c).
- (3) USEPA, February 1985.
- (4) USEPA, May 1984.
- (5) USEPA, May 22, 1985.
- (6) USEPA, November 28, 1980.
- RMCL - Recommended Maximum Contaminant Level.
- PMCL - Proposed Maximum Contaminant Level.
- NIPDWS - National Interim Primary Drinking Water Standard.
- W - The slope of the dose response curve is based on oral exposure studies conducted on animals except where noted otherwise with a capital letter. W indicates a work related (occupational) human exposure basis.
- I - Indicates an animal inhalation exposure basis.
- H - Indicates a human drinking water exposure basis.
- (a) - Values apply to halomethanes in general.
- (b) - Values apply to polynuclear aromatic hydrocarbons in general.
- (c) - Values apply to nitrosamines in general.
- (d) - Based on derived hardness of the Elizabeth River (see Appendix B).
- (e) - Based on organoleptic considerations (no relationship to human health effects documented).
- (f) - Values apply to chlorinated benzenes in general.
- (g) - Values apply to chlorinated ethenes in general.
- (10⁻⁶) - Value presented corresponds to an incremental cancer risk of 1×10^{-6} .

the site, a specialty chemicals plant directly across the river, and an auto salvage yard and numerous other potential sources of environmental contamination (industrial operations) at upstream locations.

6.4.1.2 Nature and Extent of Residual Contamination

The present extent of contamination at the site has been discussed in detail in Sections 4.0 and 5.0 of this report, but is reiterated here as this information directly supports the exposure assessment.

Samples of surface material, subsurface soil, groundwater, surface water, and sediment were collected by NUS during a Remedial Investigation (RI) conducted in 1984-1986. Analytical results for these samples provided the basis for assessing the current extent of contamination at the site.

Surficial material (new gravel fill) is presumed uncontaminated since it was added after site operations ceased. Results for samples of surface material (new gravel fill) also provide some indication that chemical contaminants are present at relatively low levels near the surface of the site.

Results for subsurface soil samples obtained during installation of monitoring wells indicate that the subsurface matrix is contaminated with a number of chemicals, most notably volatile organics, phthalate esters, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons.

Although concentrations detected in the subsurface matrix are relatively high, the groundwater does not appear to be appreciably contaminated by comparison. Although volatile organic chemicals were detected in groundwater samples, it does not appear that chemicals are presently being released from the site to a degree that would be expected in view of the subsurface soil contamination. As discussed in Section 4.0 (Hydrogeologic Investigation), the subsurface soil matrix appears to have a relatively high capacity for adsorption of organic materials. In addition, the solubilities of organic chemicals are lower in salt water than in fresh water, which may also be part of the reason that these compounds were not found in the groundwater at high concentrations.

Surface water samples obtained from the Elizabeth River were free of chemical contaminants above detectable limits except for low levels of tetrachloroethene (PCE), and pesticides and PCBs. PCE was found in one sample at a very low concentration. The pesticides and PCBs were detected at surface water sampling transects 1 and 2 (upstream and adjacent to the upstream end of the site). Only one sample contained tetrachloroethene (1.8 mg/L). One of the seep samples also contained vinyl chloride and trichloroethene.

Sediment samples obtained at five transects along the Elizabeth River revealed that the river bottom contains high concentrations of PAHs, phthalate esters, and monocyclic aromatics (benzene, toluene, xylenes, and chlorobenzene). Of the various chemicals detected, the monocyclic aromatics and PAHs display a trend that indicates that Chemical Control may have been a source. No evidence of substantial contaminant release (i.e., releases that will adversely affect the Elizabeth River) is evident under present site conditions. The data suggest that the river has and is being contaminated by other sources. An upstream sampling program has been initiated to determine the condition of the river above the site.

6.4.2 Receptors

The site is located on a heavily-industrialized peninsula between the Elizabeth River and the Arthur Kill. Because of the surrounding land uses and the cleanup procedures implemented at the site, humans are not likely to come into direct contact with onsite contaminants. However, the fire and subsequent cleanup activities (and probably Chemical Control Corporation's waste-handling procedures as well) resulted in offsite contamination. It is with this offsite contamination (contaminated river sediments in particular) that receptors could come in contact.

Receptors are limited to recreational users of the Elizabeth River and the aquatic biota that reside in the river. All contaminated surface soils both on site and off site have been covered with gravel and the site itself is enclosed by a fence, thereby effectively eliminating dermal contact with surface soil as an exposure pathway. Groundwaters and surface waters are saline, which makes ingestion an unlikely exposure scenario. For the most part, swimming and secondary contact recreation do not and will not occur in the site vicinity. However, a worst-case exposure scenario dictates that water and sediment contact and accidental ingestion of water could occur.

6.4.3 Exposure Assessment

This section presents the potential human exposure routes at the Chemical Control Site. It must be emphasized that the contamination found offsite is due to past site activities; the site is not currently contributing to offsite contamination.

Both the mode of exposure and the duration of exposure influence the resulting health impacts. Primary modes of exposure are ingestion, inhalation, and dermal contact. Ingestion may occur either directly through consumption of contaminated food, water, soil, or indirectly through recreational uses of contaminated water or sediment. Inhalation exposure results from breathing air that has become contaminated through volatilization, release of gas-phase contaminants, or entrainment of respirable particulates. When considering particulate inhalation, the physical size of the particulates, as well as their chemical

characteristics, are important in determining exposure, since the size range for "respirable" particulates is very restricted. Small particles may reach the lungs where they are absorbed into the bloodstream, but larger particles may be trapped in the esophagus where they may be expectorated or swallowed. Dermal exposure may result from direct contact with contaminated soil, water, or other material, or may involve indirect contact such as transfer of contaminants from original sources to clothing and equipment with subsequent skin contact. At this site, inhalational exposures could occur in areas where the soils were highly contaminated with volatiles that are escaping through the gravel cover material. However, volatile organic chemicals are confined primarily to the subsurface soils (see Section 4.3.3) and therefore this is an unlikely route of exposure. Ingestion of surface water could only occur coincident with recreational activity. Dermal exposures to surface waters (and possibly to sediments) are the most likely occurrences at this site where the river is used for recreation.

Exposure durations are generally divided into two classes: (1) acute exposure, which implies single time or episodic frequency of short duration; and (2) chronic exposure, which implies long-term (months and years) continuous exposure, frequent intermittent exposure, or lifetime exposure (40 to 70 years). Environmental concentrations at this site are not sufficient to cause acute toxic effects, but chronic exposure to the ambient concentrations could result in an excessive health risk.

As explained in Section 6.4.2, human receptors are limited to recreational users of the Elizabeth River. The tidal portion of the river is suitable for secondary contact recreation, therefore swimmers will be rare. There are many other more attractive areas in which to swim that will keep the number of swimmers at a minimum in this portion of the Elizabeth River. The channelized shoreline is unattractive for wading. However, boaters, fishermen, and water skiers could conceivably come in contact with the water during their activities.

Dermal contact with the river bottom sediments is unlikely because the shoreline is not a natural, sloping bank. The man-made fill is protected from erosion by a retaining wall. It is possible that young adults could choose to swim in this area, and if the water is not too deep, they could contact the sediments. The dose of a chemical from this activity is determined using the following assumptions:

- Swimming is expected to occur, on an average, of 7 days/year for 2.6 hours/day (McLaughlin, 1984) between the ages of 10 and 20.
- The body surface area of a 15-year-old child is 14,000 cm²; sediment contact area will be approximately 10 percent of the total, or 1,400 cm².

- 2.77 mg of sediment can adhere to 1 cm² of skin (McLaughlin, 1984).
- 10 percent of the contaminant is absorbed through the skin, except for heavy metals, which are not known to dermally absorbed from soils.
- A 15-year-old child weighs 40 kg.
- Life expectancy is 70 years.

The dose is calculated as the product of the contaminant contact rate and the exposure duration, or

$$Dose = \frac{C_A \times SA \times A \times E \times D \times AF}{BW \times L}$$

Where

C _A	= contaminant concentration in sediment (mg/kg)
SA	= body surface area in contact with sediments (cm ² /event)
A	= adhesion rate of sediment (mg/cm ²)
E	= number of swimming events
D	= duration of exposure (yr)
AF	= absorption factor (dimensionless)
BW	= body weight (kg)
L	= lifetime (yr)

In addition to dermal contact with the sediments, recreational users of the river will also experience a dermal contact with the water. Water is absorbed through the skin at a known rate. Using the following assumptions, the dose of a contaminant can be determined:

- A person participates in water sports on an average of 7 days/yr for 2.6 hours/day (McLaughlin, 1984) over a period of 40 years.
- The body surface area of an adult is 17,400 cm².
- The water flux through the skin is 0.5 mg/cm²-hr
- An adult weighs 70 kg.
- Life expectancy is 70 years.
- 100 percent of a contaminant in solution is absorbed through the skin.

A dose is calculated as follows:

$$Dose = \frac{C_A \times IR \times D}{BW \times L}$$

Where

C _A	= weight fraction of contaminant in water (mg/l)
D	= exposure duration (hr)
J	= water flux through skin (mg/cm ² -hr)

Coincident with boating and swimming, river water may accidentally be ingested. The total amount ingested per event will be a small portion of a person's daily intake, which is 2 liters/day. The following assumptions are made in estimating doses from this route of exposure:

- 0.2 liters of water will be ingested during each event
- A person participates in water sports for 7 days/yr for 40 years.
- An adult weighs 70 kg.
- Life expectancy is 70 years.
- 100 percent of an ingested dose is absorbed

Ingestional doses can be calculated as follows:

$$Dose = \frac{C_A \times SA \times D \times J}{BW \times L}$$

Where C_A = contaminant concentration in water (mg/l)
IR = ingestion rate (l/day)
D = exposure duration (day)

In addition, there is one final route of human exposure -- dermal contact with the leachate that flows from the banks at low tide. This exposure route is also not likely to occur. Doses would be calculated as described above for water contact, with a shorter exposure duration (perhaps 3 hours over a lifetime), and a surface area of approximately 10 percent of the body surface area (1,740 cm²).

These scenarios are considered realistic assessments of human exposure pathways at the Chemical Control Site. An attempt has been made to be conservative in assessing potential human exposure. If exposures differ from those described above, or if contaminant concentrations are not representative of areas in which the actual exposures occur, then doses will be adjusted accordingly.

Table 6-4 presents a summary of the doses incurred by receptors under the predicted exposure scenarios. These doses are presented in units of mg/kg-day. If these doses are multiplied by the receptor body weight, they become a daily dose. None of the predicted doses exceed the recommended guidelines in Table 6-3.

6.5 RISK CHARACTERIZATION

The objective of this section is to estimate the incidence of adverse health or environmental effects under the exposure scenarios defined in the preceding section. Where possible, risks are quantified. A total risk, based on EPA guidelines (USEPA, January 9, 1985) for the use of dose-additive models, is

TABLE B-4

BODY DOSES OF CONTAMINANTS (in mg/kg-day)
CHEMICAL CONTROL SITE

Contaminant	Dermal Contact with Sediment		Dermal Contact with River Water		Dermal Contact with Seep	Accidental Ingestion of River Water	
	At Maximum Concentration	At Average Concentration	At Maximum Concentration	At Average Concentration	At Maximum Concentration	At Maximum Concentration	At Average Concentration
benzene	1.1×10^{-8}	1.9×10^{-9}	ND	ND	ND	ND	ND
chloroform	2.0×10^{-9}	2.6×10^{-10}	ND	ND	ND	ND	ND
methylene chloride	1.6×10^{-8}	2.2×10^{-9}	ND	ND	ND	ND	ND
tetrachloroethene	4.0×10^{-9}	2.7×10^{-10}	6.3×10^{-8}	7.0×10^{-7}	ND	5.7×10^{-8}	6.3×10^{-9}
trichloroethene	4.0×10^{-9}	2.7×10^{-10}	ND	ND	6.2×10^{-8}	ND	ND
vinyl chloride	ND	ND	ND	ND	1.3×10^{-6}	ND	ND
total DDT/metabolites	2.8×10^{-8}	6.5×10^{-9}	ND	ND	ND	ND	ND
total PAHs	3.5×10^{-6}	7.6×10^{-7}	ND	ND	ND	ND	ND
arsenic	NA	NA	NA	NA	NA	8.0×10^{-7}	4.4×10^{-7}
chromium	NA	NA	NA	NA	NA	4.7×10^{-6}	5.4×10^{-7}

Notes:

ND - Not detected

NA - Not applicable - metals are not absorbed through the skin

used to combine the risks for individual chemicals to estimate the risks for a mixture. This section will characterize the carcinogenic, noncarcinogenic, and environmental risks at the site.

6.5.1 Carcinogenic Risks

Carcinogenic risks can be quantified by combining the dose-response assessment with an estimate of the individual intakes of a contaminant by a receptor. This document presents risks as a Unit Cancer Risk, or the excess lifetime risk due to continuous exposure to one unit of contaminant concentration (1 mg/l in water or 1 mg/l m³ in air).

Risk can be modeled as follows:

$$\text{Risk} = q^* \times \text{dose}$$

Where: q^* = Carcinogenic potency factor (slope of the dose-response curve) in kg-day/mg.

dose = Amount of a contaminant absorbed by a receptor in mg/kg-day.

Total risks for multiple compounds can be presented as the summation of the risks for individual contaminants. Calculating risks in this manner assumes that individual intakes are small, that there are no antagonistic/synergistic effects between chemicals, and that all chemicals produce the same result (cancer). Cancer risks from various exposure routes are also additive, if the exposed populations are the same.

Carcinogenic risks are calculated using a number of assumptions, therefore many uncertainties are introduced into the values. In addition to the sources of uncertainty discussed earlier (see Section 6.1.1), exposure modeling is based on several simplifying assumptions regarding age, body weight, and duration. Additivity of the toxicants and of doses of the same toxicant from different exposure routes also introduces uncertainty. The sources of uncertainty are compensated with "uncertainty factors," incorporated into the dose-response relationships. These factors will assure that while risks may be overestimated, they are not underestimated.

Table 6-4 presents a summary of worst-case carcinogenic risks presented by the site. Detailed calculations are presented in Appendix B. Maximum contaminant concentrations are used to estimate worst-case risks. The risks associated with exposure to the average concentrations of contaminants are also presented in this table which, if exposures did occur, would be the more likely case.

Again, if exposure durations or contaminant concentrations vary significantly from those presented in Section 6.4, risks will change accordingly. At this site, these exposures are not

likely to occur at a rate that approaches the durations used in the calculations, therefore risks will probably be much lower than those indicated in Table 6-5.

In general, risks from potential exposures at the site are very low, primarily because no actual receptors have been identified. The risks presented are based on speculation of several scenarios:

- People may swim in the Elizabeth River, thereby experiencing a dermal exposure to contaminants in the water and sediments.
- Swimming may also result in the accidental ingestion of the surface waters.
- Young adults and older children may, upon desire to swim, come in contact with the seep observed at the site.

Risks are determined using both maximum (an extreme, worst-case scenario) and average (a more realistic scenario) contaminant concentrations.

The total risk from exposure to multiple contaminants is presented in Table 6-5. Exposure under all scenarios is less than 1.0×10^{-4} , which is considered to be the maximum acceptable risk at CERCLA sites.

Contact with the average contaminant concentrations in the sediments would result in a risk of 8.8×10^{-6} ; contact with average water concentrations would result in a risk of 4.2×10^{-8} . The risk of exposure to sediments is due primarily to the presence of PAHs in the media. Accidental ingestion of the surface waters during swimming would result in an additional risk of 2.0×10^{-5} , primarily due to the presence of arsenic and chromium in the water. However, because the form and valence states of these metals are not known, even this risk is a gross estimation, based on the assumption that all of the arsenic and chromium present is present in their toxic forms. The risk associated with contact with the leachate seep is 2.3×10^{-8} .

6.5.2 Noncarcinogenic Risks

Risks from noncarcinogenic compounds can be characterized by comparing the expected exposure levels to acceptable levels such as the ADI. If the ratio, known as the Hazard Index, exceeds unity, there is a potential health risk associated with exposure to that particular chemical (USEPA, January 9, 1985). The Hazard Index is not a mathematical prediction of the severity of effects; it is simply a numerical indicator of the transition from acceptable to unacceptable levels.

TABLE 6-5
CARCINOGENIC RISKS
CHEMICAL CONTROL SITE

Contaminant	Dermal Contact with Sediment		Dermal Contact with Surface Water		Dermal Contact with Seep	Accidental Ingestion of Surface Water	
	At Maximum Concentration	At Average Concentration	At Maximum Concentration	At Average Concentration	At Maximum Concentration	At Maximum Concentration	At Average Concentration
benzene	3.2×10^{-10}	9.5×10^{-11}	ND	ND	ND	ND	ND
chloroform	1.4×10^{-10}	1.8×10^{-11}	ND	ND	ND	ND	ND
methylene chloride	1.0×10^{-11}	1.4×10^{-12}	ND	ND	ND	ND	ND
tetrachloroethene	2.4×10^{-10}	1.8×10^{-11}	3.8×10^{-7}	4.2×10^{-8}	ND	3.4×10^{-9}	3.8×10^{-10}
trichloroethene	4.8×10^{-11}	3.2×10^{-12}	ND	ND	7.4×10^{-10}	ND	ND
vinyl chloride	ND	ND	ND	ND	2.2×10^{-8}	ND	ND
total DDT/metabolites	8.5×10^{-9}	2.2×10^{-9}	ND	ND	ND	ND	ND
Total PAHs	4.0×10^{-6}	8.8×10^{-6}	ND	ND	ND	ND	ND
arsenic	NA	NA	NA	NA	NA	1.2×10^{-5}	6.6×10^{-6}
chromium	NA	NA	NA	NA	NA	2.0×10^{-4}	2.2×10^{-5}
	4.0×10^{-5}	8.8×10^{-6}	3.8×10^{-7}	4.2×10^{-8}	2.3×10^{-8}	2.1×10^{-4}	2.9×10^{-5}
	(1 in 25,000)	(1 in 114,000)	(1 in 2,630,000)	(1 in 24,000,000)	(1 in 43,000,000)	(1 in 4,800)	(1 in 34,500)

Notes:

ND - Contaminant was not detected in medium

NA - Not applicable

Accidental ingestion of 0.2 liters per day as estimated during recreational activities will not exceed the ADIs listed below:

Contaminant	Maximum Surface Water Conc. (mg/l)	Provisional AADI* (mg/l)
arsenic	0.025	0.10
chromium	0.155	0.17
copper	0.026	1.3
mercury	0.00016	0.005

*USEPA, November 13, 1985

The maximum detected contaminant concentrations in the surface waters do not exceed the ADIs. However, the maximum concentration of chromium is very close to the provisional AADI, and if this concentration is found to be widespread at the site, toxic effects might be expected from the accidental ingestion of chromium in surface waters.

Several contaminants identified in the groundwater at the site exceeded the chronic SNARLs (1,2-dichloroethene, trichloroethene, and tetrachloroethene). However, this fact does not result in a risk because groundwater in this area is not used as a potable water supply.

6.5.3 Environmental Impacts

This section presents information on identified receptors and associated environmental impacts at the site. Receptors are limited to the aquatic environment in the Elizabeth River adjacent to the site. The heavily-industrialized nature of the surrounding land precludes the presence of significant terrestrial habitats and animals. A June 1985 environmental impact statement prepared by the U.S. Army Corps of Engineers for dredging the Arthur Kill is the primary source of information for this section (U.S. Army Corps of Engineers, June 1985). Although this study focused on the Arthur Kill ecological systems, much of the species identification information will be relevant to the area near the mouth of the Elizabeth River.

The Arthur Kill is a component of the New York Harbor Estuarine System, connecting Raritan Bay (in the south) to Newark Bay (in the north). The northern boundary of Staten Island is formed by the Kill Van Kull, which connects Newark Bay (to the west) to Upper New York Bay (to the east). The entire area is extensively developed except for Shooters Island, which lies at

the junction of the Arthur Kill, Kill Van Kull, and Newark Bay, and the western and northwestern shores of Staten Island.

The area's natural environment has been heavily impacted by development. Water quality is degraded, but has shown slight improvement over the past few years. Recreational opportunities in the Arthur Kill are limited because of the heavy ship traffic near Howland Hook (opposite the Elizabeth River), which is one of New York's busiest marine terminals.

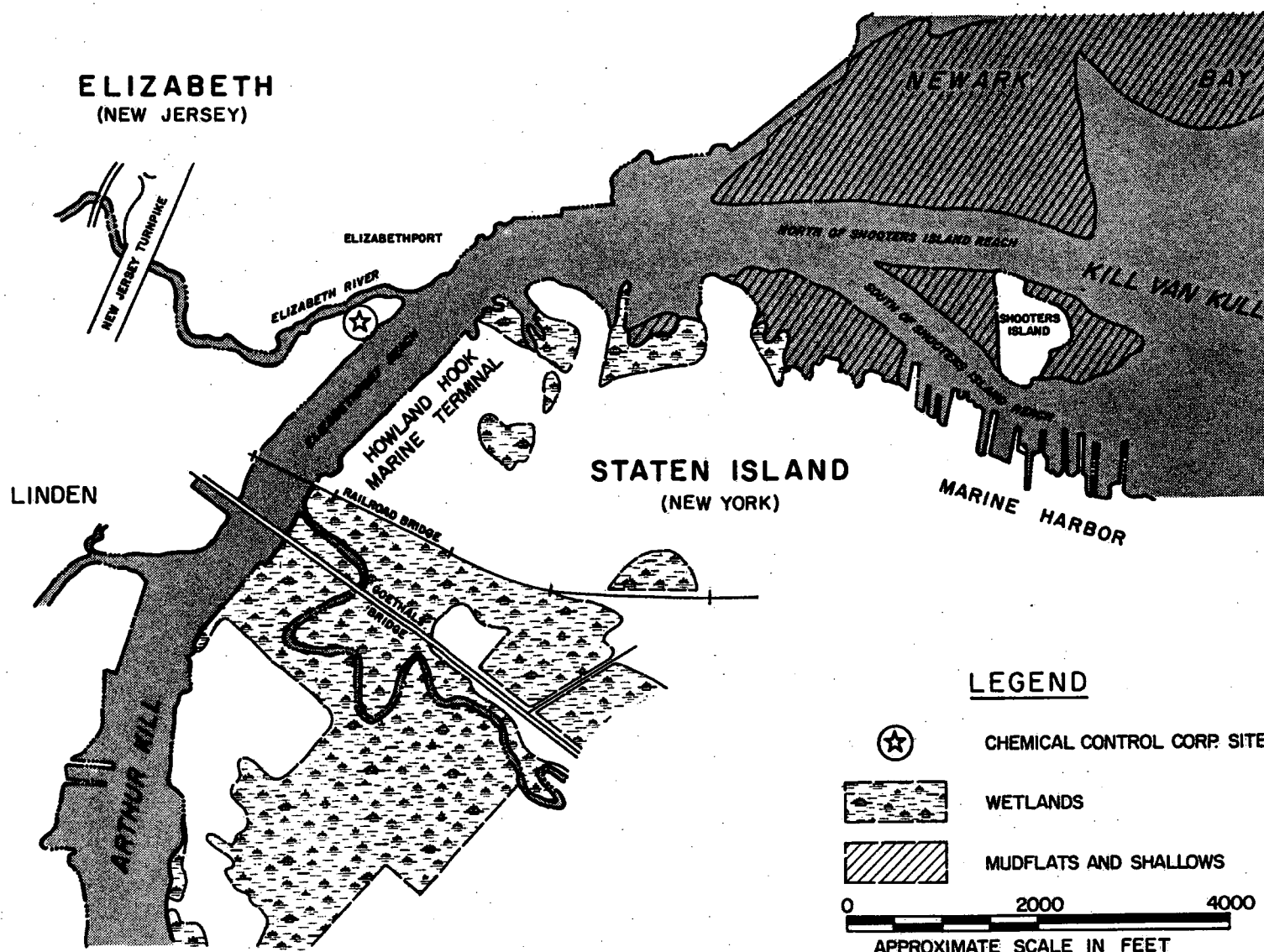
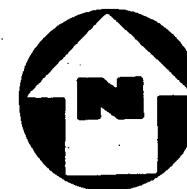
The Elizabeth River discharges approximately 24 cfs of fresh water to the Arthur Kill. The State of New Jersey classifies the tidal portion of the Elizabeth River as TW-3, the water quality criteria for which require that the river be suitable for secondary contact recreation, the maintenance of fish populations, the migration of anadromous fishes, and the maintenance of wildlife. Concentrations of nonpersistent, noncumulative compounds cannot exceed 0.05 of the 96-hour LC₅₀. Concentrations of persistent, cumulative compounds cannot exceed 0.01 of the 96-hour LC₅₀.

The waters of the Arthur Kill are classified similarly by the State of New Jersey. Low dissolved oxygen and high biological and chemical oxygen demand indicate that the wasteload of the Arthur Kill exceeds its natural assimilative capacity. Bottom sediments contain high concentrations of oil, grease, and heavy metals such as copper, chromium, nickel, cadmium, zinc, lead, and mercury. Poor tidal flushing in the channel results in critical levels (3 mg/l) of dissolved oxygen in the summer. Elimination or upgrading of sewage treatment plants in the area has generally resulted in an improvement in average dissolved oxygen levels.

Four sensitive areas were identified in the dredging environmental impact statement--Shooters Island, the wetlands near the Goethals Bridge, the mudflats in Newark Bay, and water quality. It is highly unlikely that contaminants in the Elizabeth River could adversely affect any of these four receptors, primarily because of the distance from the site and the dilution afforded by the Elizabeth River and the Arthur Kill. The water bodies and wetland areas identified thus far are shown in Figure 6-1.

Extensive biota sampling has been performed in the Arthur Kill/Newark Bay area. For the most part, sensitive species and those with restricted habitat requirements have either been entirely eliminated from the area or they are present only in particular areas or during certain times of the year. Many of the fish identified in the Arthur Kill are migratory species that are able to avoid less than favorable conditions.

In the early 1970's, benthic invertebrates in Newark Bay exhibited low density and low species diversity, with the pollution-tolerant polychaetes and oligochaetes dominating.



SENSITIVE ENVIRONMENTAL RECEPTORS
CHEMICAL CONTROL CORP. SITE, ELIZABETH, NJ

FIGURE 6-1

Shallow waters such as mudflats are more productive and provide more important food sources for fish and birds.

In 1982, the U.S. Fish and Wildlife Service (USF&WS) expressed concern over the effects of proposed channel dredging on male blue claw crabs. The numbers of blue crabs were increasing in Newark Bay and Kill Van Kull, and had been found in the Arthur Kill. Blue crabs are mobile in the summer and inhabit brackish estuarine waters. In the winter the males bury themselves in the bottom sediments and the females move to areas of higher salinity. Samples collected in February 1982 found blue crabs in the channels north and south of Shooters Island, but not in the Elizabethport reach of the Arthur Kill. The Arthur Kill apparently does not contain suitable crab habitat because tidal currents and vessel turbulence limit the deposition of fine-grained sediments. The mouth of the Elizabeth River is similarly devoid of fine-grained sediments.

From July to December 1984, the USF&WS and the Corps collected fish samples in the northern Arthur Kill and southern Newark Bay, in particular the mudflat area and the US Dike, which lies north of Shooters Island. The following species were found:

- American eel
- Alewife
- American shad
- Atlantic menhaden
- Bay anchovy
- Atlantic tomcod
- Mummichog
- Atlantic silverside
- Northern pipefish
- Striped bass
- Bluefish
- Weakfish
- Striped searobin
- Grubby
- Summer flounder
- Winter flounder

The tomcod is listed as "threatened" in the State of New Jersey. Although commercial fishing is prohibited and recreational fishing is limited by inadequate access in the Arthur Kill, several commercially-important species (bluefish, shad, flounder, weakfish, and eel) were found. Mummichog, a pollution-tolerant resident species, is by far the most dominant fish in the Arthur Kill. Migratory (anadromous) species such as the alewife are more numerous in the spring and fall than in other times of the year.

Shorebirds, wading birds, and waterfowl are numerous in the area. Aquatic birds are found in shallow waters, mudflats, or wetlands, which provide nesting and feeding areas, and habitat

for wintering waterfowl. The following aquatic birds were identified in the area:

Shorebirds	Waterfowl
black-bellied plover	red-necked grebe
semipalmated plover	horned grebe
killdeer	pie-billed grebe
willet	double-crested cormorant
greater yellowlegs	Canada goose
lesser yellowlegs	snow goose
short-billed dowitcher	brant
long-billed dowitcher	mallard
ruddy turnstone	black duck
pectoral sandpiper	pintail
knot	gadwall
dunlin	American widgeon
sanderling	shoveler
least sandpiper	blue-winged teal
semipalmated sandpiper	green-winged teal
great black-backed gull	redhead
herring gull	canvasback
ring-billed gull	greater scaup
laughing gull	lesser scaup
Bonaparte's gull	common goldeneye
common tern	bufflehead
Wading and Marsh Birds	oldsquaw
snowy egret	common scoter
great blue heron	white-winged scoter
cattle egret	surf scoter
green heron	ruddy duck
black-crowned night heron	red-breasted merganser
yellow-crowned night heron	American coot
American bittern	
least bittern	
glossy ibis	
Virginia rail	
sora	

Shooters Island provides important habitat for birds. It is surrounded by shallow flats and is isolated by debris and

pilings. It is the northernmost mixed heronry in New Jersey, and it also heavily used by waterfowl. A second rookery was discovered on Prall's Island, about 2 miles south of the Goethals Bridge.

In the southwestern corner of Newark Bay, there are 500 acres of mudflats. Their greater benthic productivity and higher dissolved oxygen levels provide habitat for fish, as well as breeding and feeding grounds for waterfowl and shorebirds. Diving ducks are reported to overwinter in this area.

There are also several tidal wetlands in the area, including tidal flats, intertidal marsh, and high marsh. Two major tidal wetlands are found at Howland Hook and near the Goethals Bridge. These 120 acres contain 10 habitat types. Other wetlands in the area have been disturbed but are still valuable to fish and wildlife. There is evidently a small wetland developing at the mouth of the Elizabeth River where the Corps placed some rocks as erosion control measures (Ducas, April 15, 1986).

The ecological value of each community is a function of its location in relation to the point of tidal ingress and its composition, productivity, and successional status. Intertidal marshes are the most productive of all tidal wetlands. Besides providing food and habitat for terrestrial and aquatic animals, they assimilate and store nutrients and sediments, and they provide a buffer zone and water storage area for storm-generated tidal surges.

The most common mammals in the area are muskrat, opossum, Norway rat, house mouse, white-footed mouse, and eastern cottontail.

It is unlikely that the environment will experience any adverse effects from the Chemical Control Site. However, if bottom-dwelling organisms (macroinvertebrates, blue crab, flounder, etc.) are found in the mouth of the Elizabeth River, food chain contamination could result from the pesticides and PAHs in the river sediments. Volatiles are not highly bioaccumulative, and therefore will not present a problem, particularly because they will readily volatilize if the sediments are disturbed by burrowing animals or tidal fluctuations.

Partitioning of the pesticides and the PAHs to the water column would result in very low concentrations that are unlikely to affect aquatic biota, that is, the concentrations would not exceed the AWQC for the protection of saltwater aquatic life, because of the great dilution effect of the 24 cfs flow rate.

No organic compounds were found at levels that exceed the AWQC for the protection of saltwater aquatic life. Of the inorganics, only nickel was found at excessive levels ($C_{max} = 193 \text{ mg/l}$, $AWQC = 140 \text{ mg/l}$). This indicates that some species may be affected by the presence of nickel in the river. No

evidence that the Chemical Control Site is the source of the nickel was identified.

The maximum downstream organic concentrations after a flood that were predicted in Section 4.6.3 do not exceed the AWQC for the protection of saltwater aquatic life. Therefore, it is unlikely that even under the worst-case flood conditions the aquatic biota will be affected by organic chemicals originating from the site.

6.6 SUMMARY

The cleanup implemented at the Chemical Control Site appears to have effectively reduced the offsite migration of contamination. The contaminated soil on and off site is covered with gravel, thereby eliminating contaminant release via erosion, and exposures via direct contact at the source. Only very low levels of volatile organic chemicals are present in the top of the old fill material. Volatilization is expected to be minimal and will not affect potential receptors because of rapid dispersion, and because a chain-link fence prohibits site access. In addition, contaminants in the groundwater do not present a risk to human receptors because the water is saline and it is not used for any potable supplies and because the chemicals appear to be bound to the solid phase.

The only contaminants with which there is a potential associated exposure and risk are those that remain in the waters and sediments of the Elizabeth River. The water itself is relatively clean except for several inorganics. There is no evidence that the site is the source of these chemicals, particularly because the entire Arthur Kill estuarine system is known to be contaminated with a number of heavy metals such as those found in the Elizabeth River. The river sediments contain a number of volatile organics, extractable organics, pesticides, and PCBs as well as inorganics. The investigation indicated that these substances are probably attributable to a number of upstream sources, although there is some evidence of impact from the site. In particular, the PAHs and the monocyclic aromatics in the sediments exhibit patterns that may be indicative of past migration of contaminants from the site. However, this is not an ongoing process.

Persons participating in water sports (boating, fishing, water skiing, and possibly swimming) in the Elizabeth River could be in contact with contaminants in the water and possibly with those in the sediment. In addition to this potential dermal contact, water could be accidentally ingested while undertaking these activities. The area is not particularly attractive for these types of activities, and water quality is not suitable for primary contact recreation (e.g., swimming), but it is always possible that these activities could occur.

The risks associated with recreation are quite small except for the regular accidental ingestion of inorganics in the water (2.9×10^{-5}) and the potential dermal contact with PAHs in the surface sediments (8.8×10^{-6}). These risks, however, fall within the 1×10^{-4} to 1×10^{-7} CERCLA guidelines for risk. Dermal contact with the surface water and leachate seep would result in a risk less than 1×10^{-6} (1 in 1 million). All risks were calculated for both a worst-case and probable scenario where these activities occur, even though no specific population of users was actually identified as potential receptors. If either contaminant concentrations or potential exposure scenarios differ from those identified in this report, risks will be adjusted accordingly.

The contaminated sediments in the Elizabeth River may present a hazard to bottom-dwelling aquatic biota. However, because this ecosystem is already stressed as a result of industrial activity and wastewater treatment plant discharges, the effects due specifically to the Chemical Control Site cannot be differentiated without a detailed biota survey and sampling program. It appears that, at the present time, contaminants are not entering the water in measurable quantities. The vast dilution capacity of the Elizabeth River and the low solubility of many compounds in salt water effectively eliminate environmental impacts. A survey and sampling program could perhaps shed some light on the effects of residual contamination in the river.

In conclusion, the site in its present condition does not pose a threat to either human or environmental receptors. Any health threats or adverse impacts from the site are attributable to the contaminants that were released to the Elizabeth River in the past. While the RI revealed that the site has impacted the river to some extent, these impacts appear inconsequential in view of poor water quality of the river as a result of upstream industrial and municipal discharges.

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